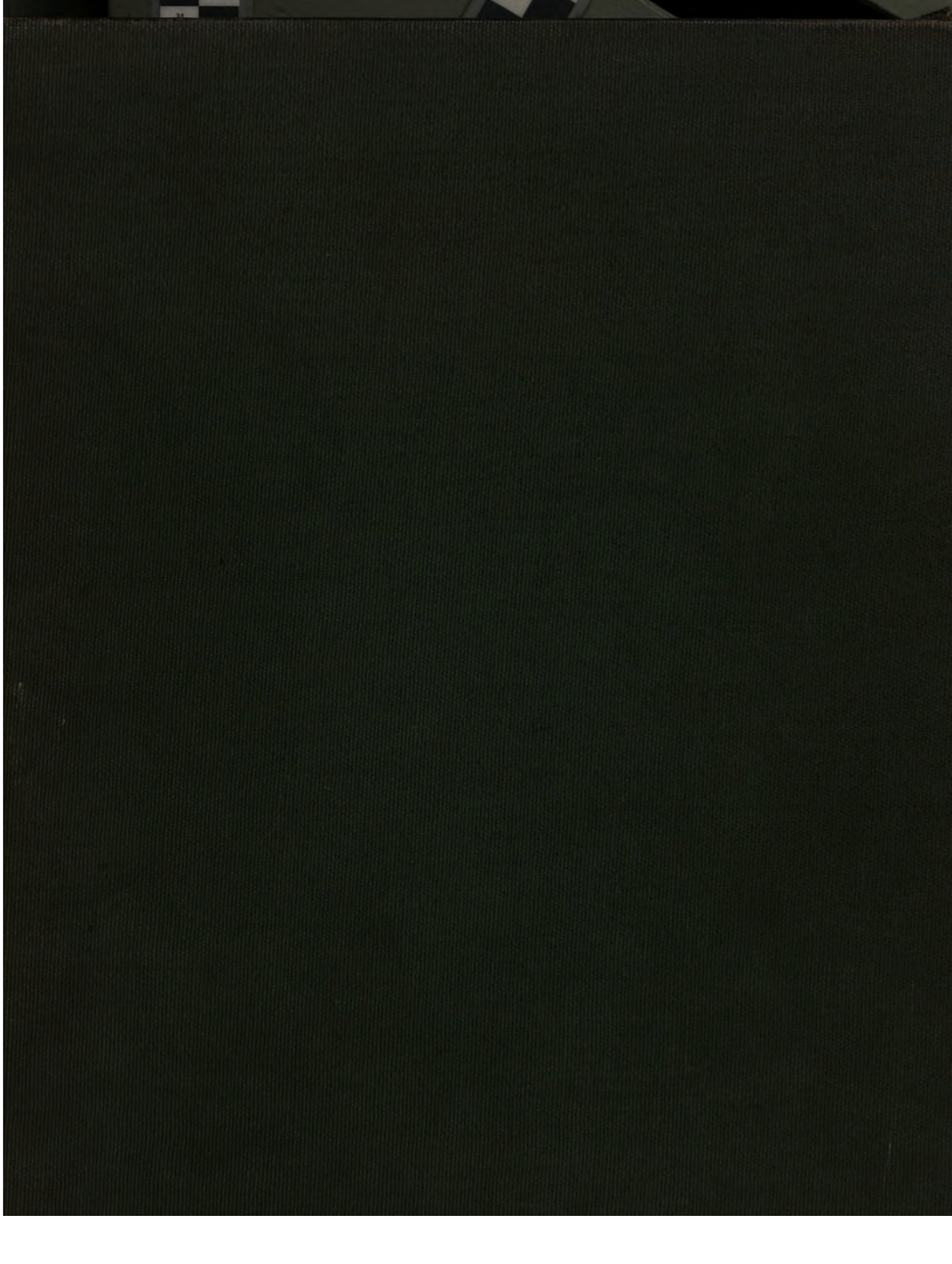

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Archives

— of —

Clinical Skiagraphy.

BY

SYDNEY ROWLAND, B.A., CAMB.,

LATE SCHOLAR OF DOWNING COLLEGE, CAMBRIDGE, AND SHUTER SCHOLAR OF ST. BARTHOLOMEW'S HOSPITAL.

SPECIAL COMMISSIONER TO "BRITISH MEDICAL JOURNAL" FOR INVESTIGATION OF THE APPLICATIONS OF THE NEW PHOTOGRAPHY TO MEDICINE AND SURGERY.

A SERIES OF COLLOTYPE ILLUSTRATIONS WITH DESCRIPTIVE TEXT, ILLUSTRATING APPLICATIONS OF THE NEW PHOTOGRAPHY TO MEDICINE AND SURGERY.

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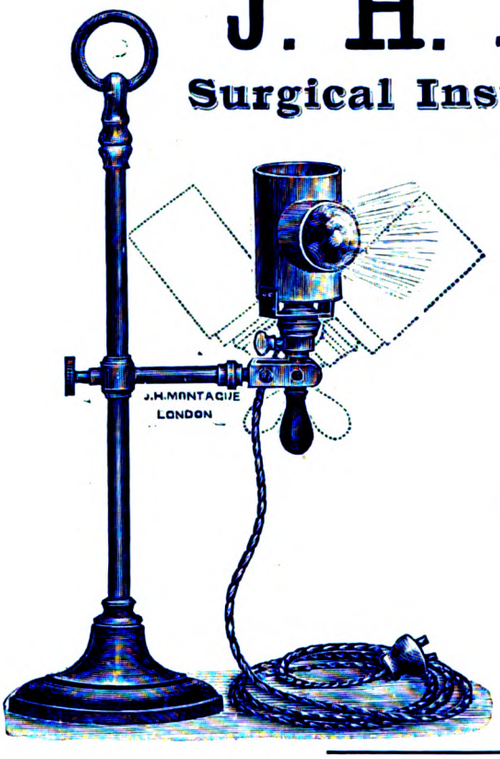

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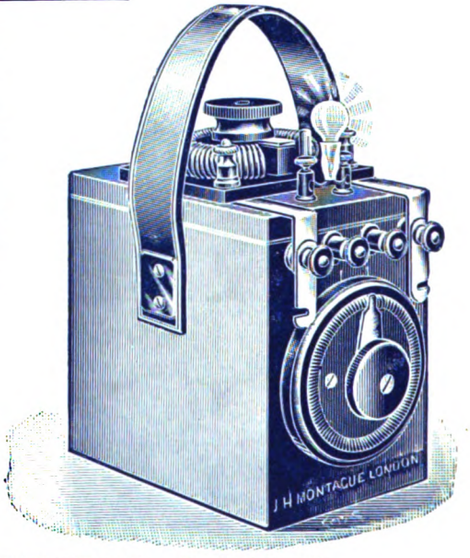

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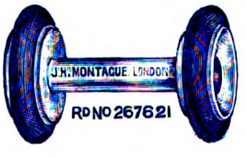

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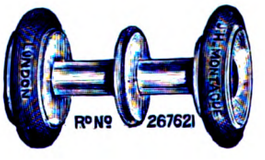

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PREFACE.

THE object of this publication is to put on record in permanent form some of the most striking applications of the New Photography to the needs of Medicine and Surgery.

The progress of this new Art has been so rapid that, although Prof. Röntgen's discovery is only a thing of yesterday, it has already taken its place among the approved and accepted aids to diagnosis. At the first moment, the statement that it had been found possible to penetrate the fleshy coverings of the bones, and to photograph their substance and contour, seemed the realization of almost an impossible scientific dream. The first essays were of a rough and imperfect character; week after week, however, improvements have been made in the practical application of the Art, which I venture to call Skiagraphy; and, at the present time, we are in a position to obtain a visible image of every bone and joint in the body. In essence the process is nothing more than the photographic representation of the shadow cast by the opaque bony structures, or by metallic foreign bodies, on sensitized plates. The greater part of the practical improvements that have led to the present stage of perfection of the process have been made in this country, and in some of these I have been so fortunate as to take part.

2821

In the plates presented in this first number of a publication which will, I hope, take a permanent place in Medical literature, I have presented some examples of the more difficult and instructive achievements of Skiagraphy up to this date: and it is permissible to hope that, as time goes on, in addition to drawing upon the storehouse of Skiagraphic clinical records which I have already massed, it will be our good fortune to be able to present results more striking and of increasing importance from other workers in the new field.

I have to offer my thanks to the many Medical men who have favoured me with the opportunity of investigating and reproducing my pictures of cases under their charge, and for their permission to use the material as published. I have also to thank Mr. Herbert Newton for valuable practical assistance in perfecting methods and apparatus, both in photographic illustration and in Skiascopic examination—a procedure of which I shall have to speak hereafter.

SYDNEY ROWLAND.

429, STRAND,

April 2nd, 1896.

INTRODUCTION.

If a glass bulb, in which two platinum wires are fused through the glass, be connected with an air pump, and the wires be connected with an induction coil, and if the bulb be gradually exhausted, the following theories of phenomena will be observed to take place:—As the air is pumped out and the pressure falls, the spark gradually loses its well-known characteristics, and finally ceases to be a spark at all. The tube is now seen to be filled with a glowing column of light, which, on close observation, will be seen to be arranged in layers. This is the so-called stratified discharge. If the exhaustion be carried to a still higher pitch, a dark space will be seen to appear at the point at which the current leaves the tube (cathode); and, if it be pushed still further, this dark space (which was discovered by Crookes, and is called Crookes' space) will be seen to widen out, till finally the whole tube may be said to be occupied by the dark space, and the only evidence we have that a discharge is taking place is a brilliant greenish phosphorescence of the glass walls. It is at this point that the science of the New Photography may be said to commence.

From the phosphorescent glass there proceed in all directions the rays which were discovered by Prof. Röntgen, and provisionally named by him, for want of a better title, the X rays. As is now well known, the peculiarity of these rays is that they have a standard of transparency entirely their own. Thus many of the substances which are ordinarily opaque to light, as we know it, permit the passage of this form with ease. Thus, on the one hand, carbon, as is ordinarily used for battery plates, is extremely transparent, while on the other hand the most lucid glass is extremely opaque. Such a glass bulb, per-

manently exhausted and hermetically sealed, is known, from the name of the investigator who first studied the characters of an electric discharge in vacuo, as a Crookes' tube. This, or a slight modification of it, was the form of tube which Prof. Röntgen employed when he made his memorable discovery. With such a tube much good work was done, but the results obtained by its use are not to be compared with those which have been obtained with far greater ease and more certainty by the use of a modification of the original form introduced by Mr. Herbert Jackson, of King's College, London. I myself proposed the use of the same modification independently, but on inquiring at the instrument makers, with a view to having some made for me, I was told that they had already been at work on the same tube for some days. From the fact that in this tube the cathode plate, which is a concave disc of aluminium, focusses the cathode rays at a point near the centre of the bulb, the name focus tube has been applied to it. The anode plate is a small piece of platinum foil placed at an angle, a short distance beyond the focus of the cathode rays. Curiously enough the cathode rays do not cross like rays of light at the focal point, but behave rather like a number of fluid jets coalescing and proceeding onwards as a solid parallel vein. The point where the rays impinge on the platinum still retains its small dimensions, though the plate is placed some distance beyond the focal point. The platinum is known to be one of the most opaque substances to cathode rays, and thus very little of the radiation passes through the platinum foil. The greatest part of the radiation is absorbed by the platinum, and given out as X rays from the luminous point by a kind of diffuse reflection. The anode plate being set at an angle, the best part of the radiation is directed downwards through the sides of the bulb.

PROF. RÖNTGEN'S ORIGINAL EXPERIMENT.

It will be remembered that the original experiment of Prof. Röntgen which led to his discovery of the X rays consisted in an observation that paper coated with barium platino-cyanide lit up with brilliant fluorescence if brought within the sphere of influence of an

excited Crookes' tube covered with black paper. From this discovery Röntgen argued the existence of certain rays which were able to traverse black paper, and by inference other opaque substances, as evidenced by their affecting the barium platino-cyanide, which deduction has been so strikingly substantiated by the vast amount of work that has been done in the field of the New Photography. And in no direction has the discovery borne such practical and important fruit as in its application to Medicine and Surgery.

Some few weeks after the discovery of Röntgen, Prof. Salvioni, of Perugia, announced that he had (apparently independently) arrived at this property of the platino-cyanides of fluorescing under the influence of X rays, and had turned it to practical account by the construction of an instrument called a cryptoscope.

Salvioni's cryptoscope consisted simply of a surface of some substance opaque to light, but capable of transmitting the X rays, coated thickly with the fluorescent salt—in his case barium platino-cyanide. Since this announcement reached England—now some six weeks ago—the same fact has been reported over and over again by several workers. It is curious to note the zeal with which the newspaper reporter has seized on these successive announcements and magnified them into fresh discoveries. This craving for exciting news has been at no time better exemplified than in the extended and "booming" reports that were circulated as a result of Edison's simple telegram to Lord Kelvin. The facts of the case are, that very many substances behave as do the platino-cyanides, and that Edison simply telegraphed that he had found tungstate of soda to fluoresce more brilliantly than salts that had hitherto been tried. Whether this is so or not remains to be proved in this country. But great as has been the success of observers in other countries, it has remained for England to produce the instrument in its perfected and simplified form, and for Mr. Herbert Jackson, of King's College, to fix on the particular salt which gave the best results—results besides which all previous attempts are cast into the shade. The salt he employs is the platino-cyanide of potassium.

CONSTRUCTION OF THE INSTRUMENT.

In its latest and most perfect form the instrument simply consists of a circular sheet of black cardboard, covered on one side with the salt above named, and protected by a glass plate. To prepare the salt for spreading on the card so as to ensure the best results is a work of considerable difficulty, and it is only within the last few days that these difficulties have been overcome. The method that has been found to answer best is as follows: A sufficiency of the salt is ground to the finest powder in an agate mortar. The finely-divided substance is then made into a thick cream, with enough gum arabic to produce a mass of the requisite viscidity to adhere to the card. On the card the mass is then spread in as even a layer as possible, and the instrument is complete.

EXPLANATION OF EFFECT PRODUCED.

When such a prepared screen is placed in the path of the X rays, it is seen to light up with a vivid green light. Given that some object capable of obstructing the rays is placed between the source of these rays and the screen, it is obvious that a dark shadow of the object is cast on the screen, and is seen as such by the eye, the screen having converted X rays into light rays, as evidenced by its fluorescence.

On the accompanying diagram the effect is rendered clear. The

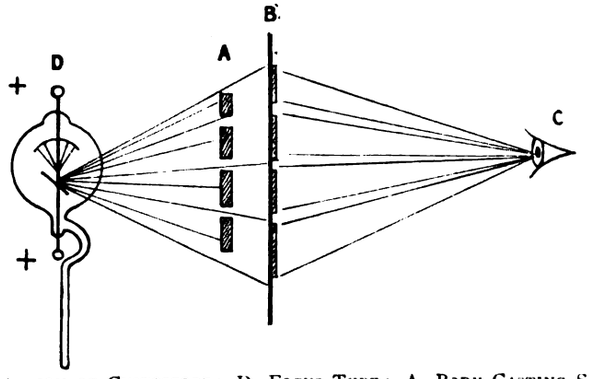


DIAGRAM OF ACTION OF CYSTOSCOPE: D, FOCUS TUBE; A, BODY CASTING SHADOW ON B, FLUORESCENT SCREEN WHICH IS SEEN BY EYE AT C.

object casting the shadow is, for simplicity's sake, represented on a perforated sheet, but the same effect would obviously be produced when the object is the human hand, for example. In this case the flesh, being transparent, casts no shadow, while the bones, being relatively opaque, cast a definite and clear image.

It must not be forgotten that the success of this instrument depends on having at command a definite and minute point of origin for the X rays. Such a point is furnished at the place where the cathode rays from the concave electrode of the focus tube strike the platinum plate. Thus, it is largely owing to the invention of this tube that the apparatus has succeeded so well in this country.

Whatever may be the scientific explanation of the exact character of the X rays, the value of their discovery to surgeons and physicians is inestimable. By means of the new radiation it is now possible to render visible certain of the interior structures of the living body, and their precise conditions of disease or of health can be objectively demonstrated, and facts which heretofore could not be known or guessed at by a complicated system of inference, are now *oculis subjecta fidelibus*. Many and various have been the extravagant stories and reports which have been circulated as the result of the Wurzburg professor's discovery. Thus, from America we have heard that Edison has been at work on photographing a human brain, and even he has been forestalled by another Transatlantic investigator in accomplishing the same object. The very manner in which these reports have reached our papers at once stamps them as canards or the result of gross ignorance on the part of those who promulgated them. Whatever may be the possibilities of the New process, it is certain that the brain will be one of the last regions to be brought within its sphere of influence.

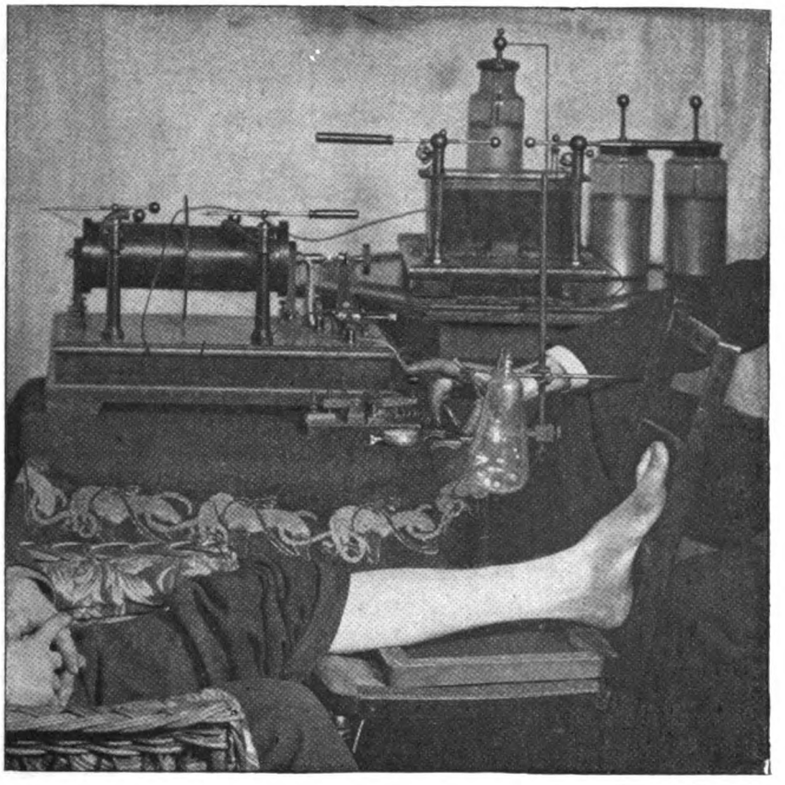
WHAT THE NEW PROCESS CAN AND WHAT IT CANNOT DO.

Here it may be as well to define, as accurately as present knowledge will permit, what the new science of skiagraphy will or will not accomplish. The very essence of the process consists in the fact that certain structures in the body, or foreign materials which may have found

their way into it, are more or less permeable to these X rays than the tissues in which they may be imbedded. Thus, in the case of a bullet, imbedded in the bones of the wrist, the bullet will impede the progress of the rays more than the bones, and these in their turn more than the flesh that surrounds them. In order, therefore, to obtain a picture showing the state of things, it is necessary to lay the wrist on the surface of a sensitized plate and to place the tube, from which the rays proceed, on the other side (back or front) of the wrist. Under these conditions the rays will pass more or less completely through the flesh, and its shadow on the plate will be more or less a dark one. The bones, on the other hand, will impede the passage of the rays to a far greater extent, and their shadow will, therefore, be a light one. The bullet being the most opaque of the three, will almost entirely stop the passage of the rays, and will consequently appear as a white spot.

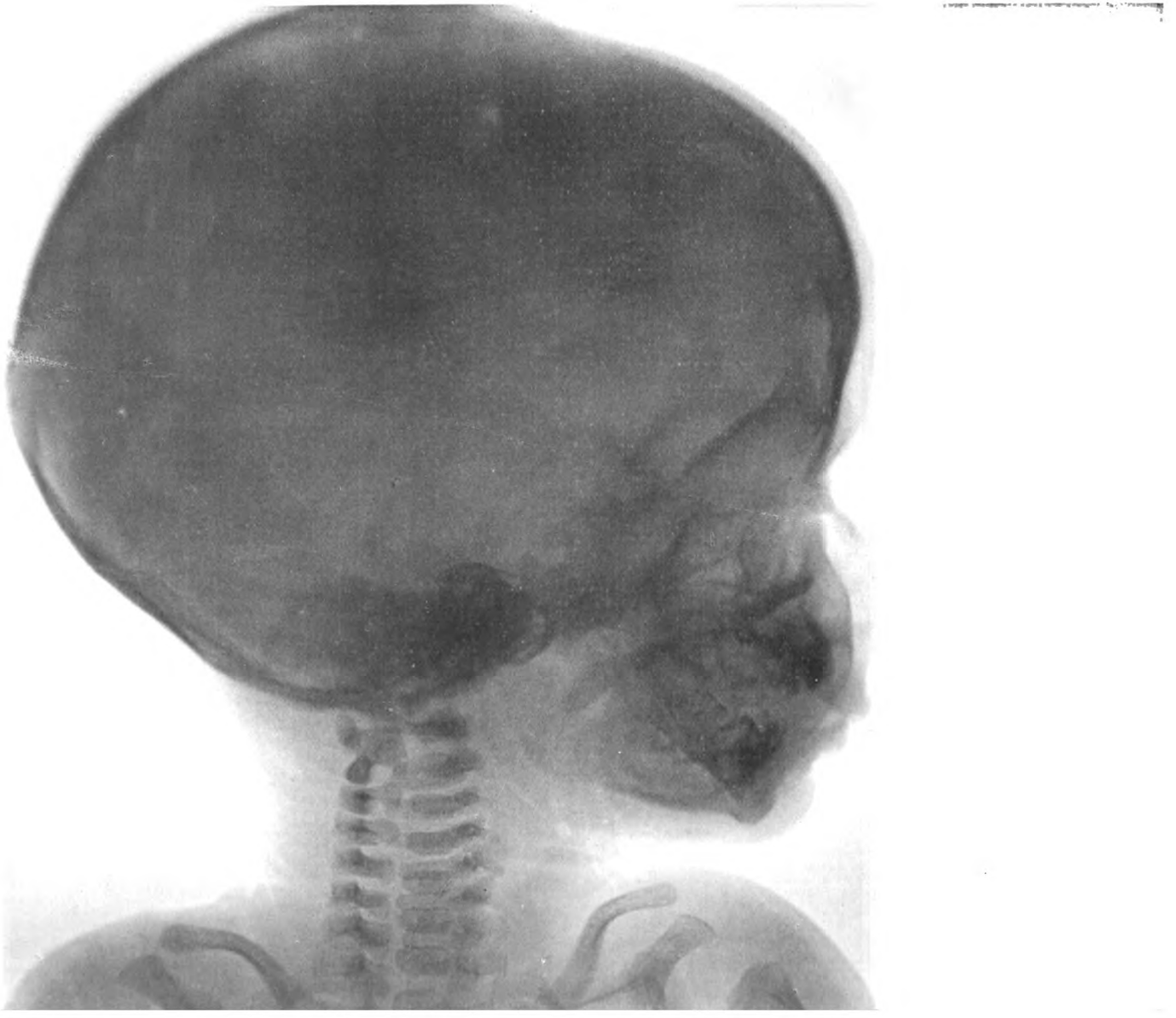
From what has already been said, a fair idea may be gained of the present condition of the new process. Fresh developments are daily being made, and eventually, it may be anticipated, will reach some such point as this :—In all cases of bony disease the present methods of diagnosis will be supplemented by skiagraphy. In bony diseases, par excellence, is the importance of an early recognition most urgent, for having located the mischief, the surgeon can in very many cases remove the diseased area, and so assist Nature in bringing about a rapid cure.

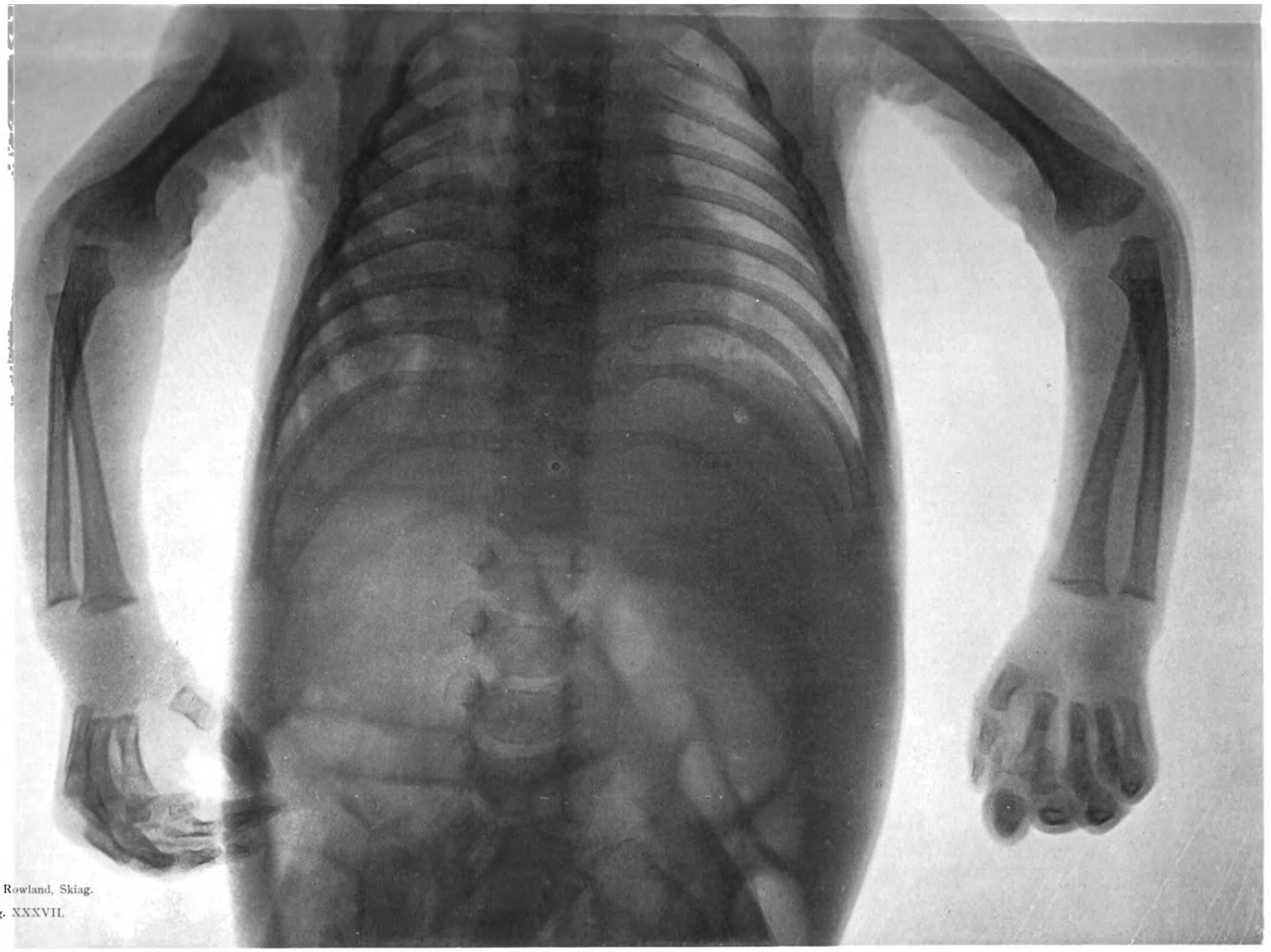
In bony diseases, then, will the process be especially useful, for the reasons already given—that the bones stand out as presenting the greatest contrast to the rest of the tissues in the matter of transparency.



PHOTOGRAPH OF APPARATUS AND METHOD EMPLOYED FOR OBTAINING A SKIAGRAM. IN THIS CASE THE LEG.

Plate 1 and 2.





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CHILD—SKIAGRAM OF SKELETON OF FULL GROWN CHILD, AGED THREE MONTHS. NOTE THAT THE INTESTINES, HEART, AND LIVER, CAST DEFINITE SHADOWS.

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SKIAGRAM OF HAND WITH NEEDLE IMBEDDED IN FINGER.

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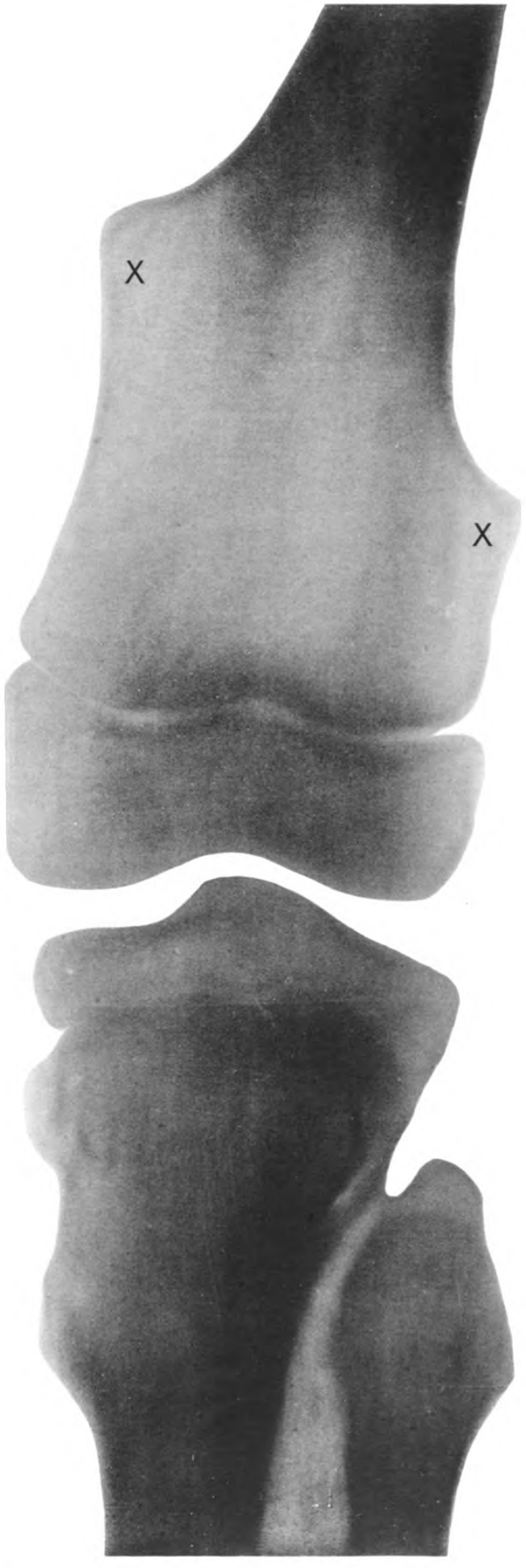

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SKIAGRAM OF KNEE JOINT, FROM A CASE OF MULTIPLE EXOSTOSIS.

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SKIAGRAM OF WRIST AND FOREARM,* SYPHILITIC OF RADIUS. X INDICATES POSITION OF GUMMA.

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* Should read "Syphilitic Disease of Radius."

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SKIAGRAM OF HAND, WRIST, AND FOREARM, FROM CASE AS No. XLI.

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DESCRIPTION OF PLATES.

PLATES I. AND II. (*Exposure 14 minutes.*)

(DOUBLE PAGE PLATE OF CHILD.)

This double plate illustrates very successfully the skeleton of a full-grown child, aged three months. The intestines, heart, and liver cast definite shadows, and can be easily distinguished. This skiagram is the first step in the direction of obtaining photographic records of the condition of the soft parts. No doubt in the near future such will be possible in the case of adults; at present it is only possible in the case of infants and small animals.

PLATE III. *(Exposure 2 minutes.)*

DETECTION OF NEEDLE IMBEDDED IN FINGER.

This plate illustrates very well the usefulness of the process in the detection of foreign bodies lodged in the soft parts. It is one of many similar cases that I have successfully skiagraphed, and of which I may mention the following:—Discovery of a halfpenny in the intestine of a child. Location of a bullet in thigh of a man. Location of needles in various parts of the body in numerous cases, and many others. For the notes of the present example I am indebted to Mr. Battle, under whose care the case was at the Royal Free Hospital:

C. P., aged fifty-six, came to the Royal Free Hospital on March 4th, 1896, complaining of having run a piece of needle in her right

index finger on March 1st. There was considerable redness and swelling about the middle of the finger, especially on the outer and palmar surfaces, but no foreign body could be felt.

I took a skiagram of the finger at Mr. Battle's request, and the piece of needle was seen to be lying close to the radial side of the second phalanx of the index finger. On March 6th the finger was more inflamed, and a pustule had formed about the middle of the palmar surface of the second phalanx, where the needle was said to have entered.

Mr. Battle asked Mr. Bottomley to remove the needle. Ether spray having been applied, an incision was made along the radial border of the second phalanx of the index finger, and the piece of needle was found lying close to the bone, and extracted; it was a fragment about $\frac{5}{8}$ inch in length.

PLATE IV. *(Exposure 9 minutes.)* PLATE VI. *(Exposure 3 minutes.)*

MULTIPLE EXOSTOSES.

The next two plates are from the same case. Multiple exostoses, under the care of Dr. Dawson Williams, at the East London Children's Hospital, Shadwell. The plates speak for themselves, and do not need detailed description. For the notes I am indebted to Dr. Dawson Williams.

The patient was a girl, aged nine years. The distribution of the exostoses is generally symmetrical, but their size and form do not correspond completely on the two sides. The largest is on the right femur, about three inches above the knee joint. On palpation it appeared to occupy the inner and posterior aspect, and to be rounded in form with a broad base. The skiagram shows, however, that it is cone-shaped, and also that there is another similar growth on the outer side, just above the epiphysis.

It is noticeable that both these growths appear to have been somewhat more transparent to the X rays than the shaft of the bone.

On the left femur, on the inner aspect, about two inches above the inner condyle, a smaller growth can be felt.

The skiagram shows also a bony nodule on the inner aspect of the right tibia, a little below the internal tuberosity, and there is a similar but much smaller nodule at the corresponding part of the left tibia, which has also three small nodules at the base of the inner malleolus.

The hand shown in the other skiagram from this case presents an interesting deformity, of which the cause is clearly displayed. At the base of the first phalanx of the little finger is a bony growth, which has displaced the whole finger inward, and it is curious to note that a compensatory curve at the last inter-phalangeal joint appears to have been established. This exostosis also is seen to have been more transparent than the rest of the phalanx. This fact seems to render it probable that the growth is composed of cancellous tissue. There is also some overgrowth connected with the inner aspect of the first phalanx of the index finger, which has displaced the two terminal phalanges outward. There is a similar deformity to be felt at the outer side of the base of the middle phalanx of the middle finger on the opposite side.

This skiagram of the hand shows very well the condition of ossification at this age (nine years). In particular the epiphysis at the proximal extremity of the metacarpal bone of the thumb is very conspicuous. It is seen also that the epiphysis of the proximal phalanx of the little finger is not involved in the exostosis, which has in fact formed a spur on the outer side, so that the epiphysis lies in a kind of cup. In the wrist the bones which are largest, and possess most nearly their adult form, are the os magnum, the unciform, and the cuneiform. In all these bones the ossification begins before the third year (first, second, and third years respectively). The semilunar and trapezium, in which ossification begins in the fifth year, are small, and have not their characteristic form and shape. The diminutive size of the scaphoid bone, which begins to ossify in the eighth year, is striking, while the pisiform, in which ossification does not commence until the eleventh or twelfth year, does not show at all in the

skiagram. The trapezoid bone is more conspicuous than in most skiagrams of the wrist, and larger than might have been expected in view of the fact that ossification does not usually begin in it until the eighth or ninth year. It is interesting to compare the condition of the wrist in this skiagram with that shown in the wrist of the infant in Plate I. In the infant there are no signs of any ossification in the wrist, nor are the lower epiphyses of the radius and ulna visible, whereas in the wrist of the child they are of considerable size.

PLATE V. *(Exposure 6 minutes.)*

SKIAGRAM OF WRIST AND FOREARM, FROM A CASE OF SYPHILIS. INDICATES POSITION OF A GUMMA.

This skiagram is from a case of congenital syphilis. It shows atrophy and a condition of greenstick fracture of the radius. X indicates the site of a gumma. For the notes I am indebted to Dr. Phillips:

C. S., aged fifteen; a thin, unhealthy-looking boy. Nodes on anterior fontanelle on frontal bone and on temporal ridges on each side. No craniotabes. Right ulna felt to be thickened; also left tibia in its upper third. The right arm is held midway between pronation and supination, these movements being nearly but not quite absent. The ulna is felt to be thickened just below the centre of the bone. The radius is felt to be of normal thickness for about two inches from the lower end; the bone then diminishes rapidly, and is continued on as a thin, bony shaft, returning to its normal thickness two inches from the head. It is, apparently, fixed to the ulna, though some movement can be obtained. Over the atrophied part of the bone is a large scar, covered with thin, transparent skin. The wrist is held in position of adduction, the head of the ulna being very prominent and the whole bone being curved.

PLATE VII.

HYPERTROPHIC OSTEO-SCLEROSIS OF FIBULA.

By F. C. ABBOTT, F.R.C.S., Resident Assistant Surgeon to St. Thomas's Hospital.

Male, aged seventeen. Admitted to St. Thomas's Hospital under the care of Mr. Clutton. For five months past the right leg has ached after walking and playing football. There is no history of injury. He is not clear when he first noticed the tumour, but it had been getting larger for the last few days before admission to the hospital.

A hard, apparently bony, tumour is situated around the lower half of the right fibula, about three and a half by two inches, not tender to touch, and does not involve the skin. Its main position is behind the fibula, and the external surface is but slightly involved, and here the outline of the bone itself can be traced. The bone cannot be felt to be expanded, and there is no bony crackling, the growth appearing to be around and not in the bone. (This was shown not to be the case by the skiagram.) The tendons can be felt passing over it, and the soft tissues are somewhat thickened behind. The surface is mainly smooth, but in parts nodular.

The tumour was cut down upon, and proved to be a general fusiform enlargement of the fibula with sclerosis of the bone; in fact, a true hypertrophic osteo-sclerosis. The cause is quite unknown. A portion of the bone was resected for examination, but nothing more was made out. It was simply dense bone, as the skiagram represented.

Note on the Skiagram.—This plate represents the middle thirds of the tibia and fibula of the patient before mentioned. The original diagnosis in this case suggested itself as sarcoma. The skiagram was taken with the idea that it might possibly throw some light on the subject; and although it did not completely clear up the diagnosis, this was due to our then want of knowledge of the appearance of a sarcoma

in a shadow picture. Since that time I have had the opportunity of skiagraphing an undoubted central sarcoma of the tibia, and on comparing the two cases it is seen that the sarcoma is transparent in its central parts, and far less clearly indicated generally than is the tumour seen in the plate. Had this fact been known at the time it would doubtless have thrown much light on the case and eliminated central sarcoma from the diagnosis, and it will be henceforth available.

S. R.

PLATE VIII.

REVOLVER BULLET IN PALM OF HAND.

This skiagram is introduced to show the possibility which the new method holds out of throwing light on intrinsic bone disease. The fact that bone is not absolutely opaque to X rays, but only relatively so as compared with the soft tissues, renders this possible. In the skiagram it will be noticed that the ends of the metacarpals and the entire phalanges indicate their detailed bony structure. To effect this the rays must have traversed the bone. It is curious to remark that the resulting picture has all the appearance of solidity. This appearance bears out the now universally accepted theory of the mechanical structure of bone, and is an expression of the fact that the external configuration bears intimate relations to the internal structure.

S. R.

PLATES IX. AND X.

A COMPLICATED FRACTURE OF THE TIBIA EXTENDING INTO THE KNEE JOINT.

By Surg. Lieut.-Col. STEVENSON, R.V.H., Netley.

A fracture of the femur at about three inches above the condyles was produced in a man, aged thirty-three, by indirect violence. On

the day after the accident I examined the case, and found the signs of the injury at the point above named to be very evident. There was no shortening, no depression of the upper end of the lower fragment into the popliteal space, and no increase of width across the condyles. Ten days later Mr. Sydney Rowland made two skiagraphs of the case, one from side to side, and another from the front to the back, with an exposure of fourteen minutes and ten minutes respectively; at this time one inch shortening could be measured. From both pictures together the condition of the fracture could be perfectly seen. The first one, from side to side, shows the shortening and the partial separation of the fragments, and the second shows a line of splitting from the site of the fracture into the joint through the intercondyloid notch. The advantage of the new photography in this case, both as regards prognosis and treatment, can hardly be overrated.

Notes on the Skiagram.—The subject of these two plates is one of which it is very difficult to obtain a really satisfactory skiagram. Owing to the great breadth of the lower end of the femur from condyle to condyle, it must of necessity happen that there is very great variation in the distance of the various parts from the photographic plate. Hence one condyle is apparently seen through the other, the condyle next the plate appearing much denser, but, being overshadowed by its fellow, not so well defined.

Plate IX.—The oblique white streak running from above downwards, and from left to right, is the same line of fracture seen in the next plate.

In addition, the same shell of bone elevated from the shaft is seen to extend beneath the patella.

Plate X.—The line of fracture in this plate is seen to run between the two condyles. At the same time a thin shell of bone has been raised from the shaft. This is seen in the plate on the left-hand side, between the edge of the bone and the dotted line extending upward from the patella. S. R.

PLATES XI. AND XII.

ANOMALOUS DEFORMITY OF HANDS AND FEET.

By RICHARD BARWELL, F.R.C.S., late Senior Surgeon to Charing Cross Hospital.

The lad whose extremities are shown in the subjoined skiagrams is sixteen years old, inmate of a home under my surgical care.

I am engaged, together with Mr. Sydney Rowland, in arranging for publication a series of skiagrams of foot deformities. But as this particular case does not fit in with our intended series it seemed well to us to let it take a separate place in the ARCHIVES OF CLINICAL SKIAGRAPHY. The deformities are in all probability not congenital, but originate in early osseous development, being due to false location and insufficient power of the osseous nuclei. This condition only affects the extremities; the trunk and the limbs, though the boy is rather short, are well formed.

In the left hand the bones of the second finger, normal in length, show out well and black, ossification is there complete. The whole of the hand did not unfortunately fall on the plate; but the bones of the fourth finger seem well formed, the metacarpal being strong with a properly formed base and epiphysial head.

With these exceptions all the metacarpal bones and phalanges are more or less deformed; the carpus, though not fully ossified and therefore difficult of comparison, seems normal. In the left hand the first phalanx of the thumb (2) and the second phalanx of the index (3) are almost entirely absent, or are only represented by a deformed piece of cartilage, which, being transparent to X rays, is not marked definitely enough to admit of clear description. The first phalanx of the index (4) ends in a globular enlargement. The metacarpal bone of the ring finger (5) ends in what is probably a semi-cartilaginous mass compounded of the epiphyses of that bone, mixed up with the epiphysis and diaphysis of the first phalanx, and with the epiphysial end of the

Sydney Rowland, Skiag.

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SKIAGRAM OF SARCOMA (?) OF FIBULA.

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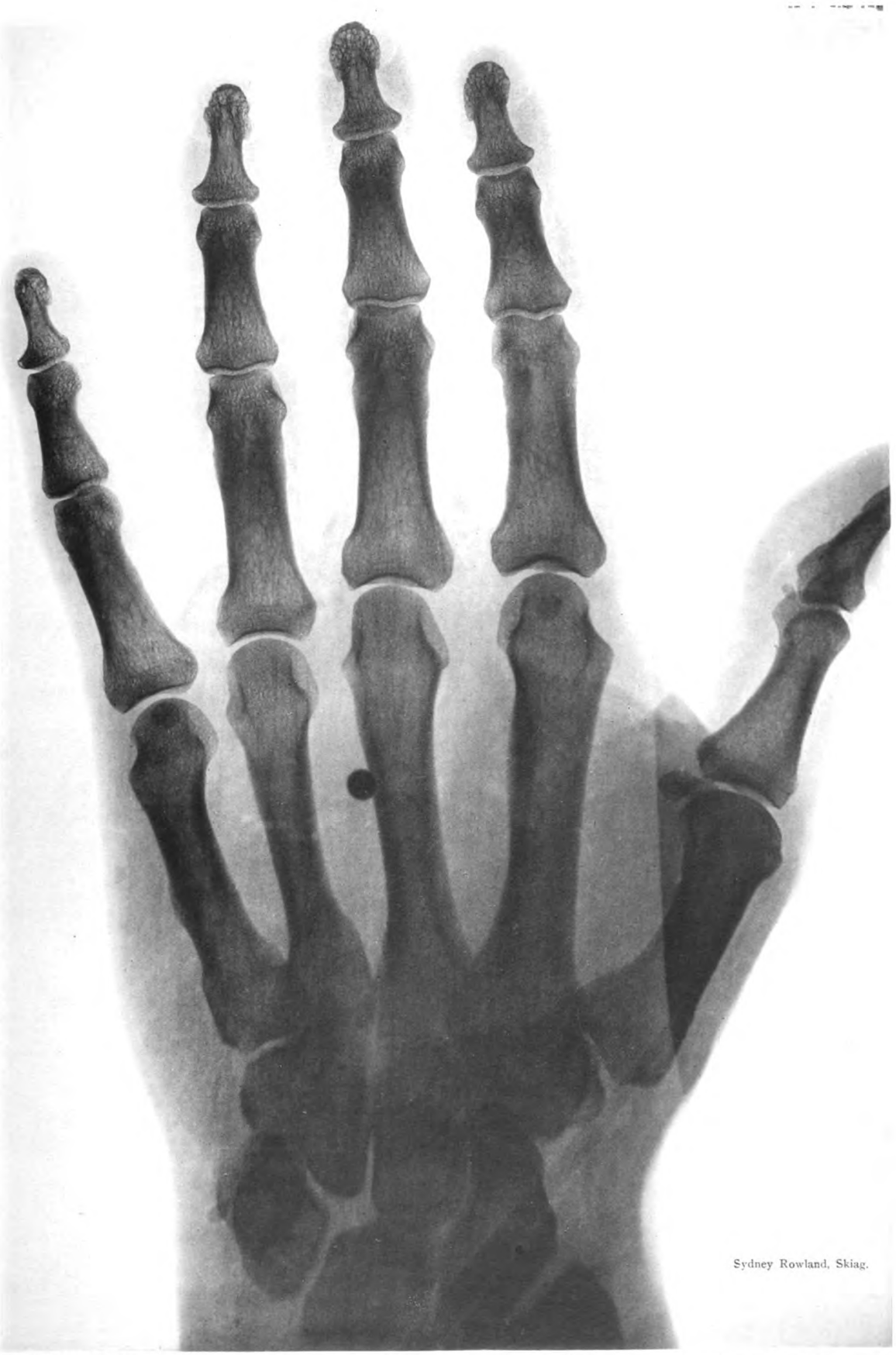

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SKIAGRAM OF REVOLVER BULLET IN HAND.

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SKIAGRAM OF FRACTURE OF FEMUR EXTENDING INTO KNEE JOINT.

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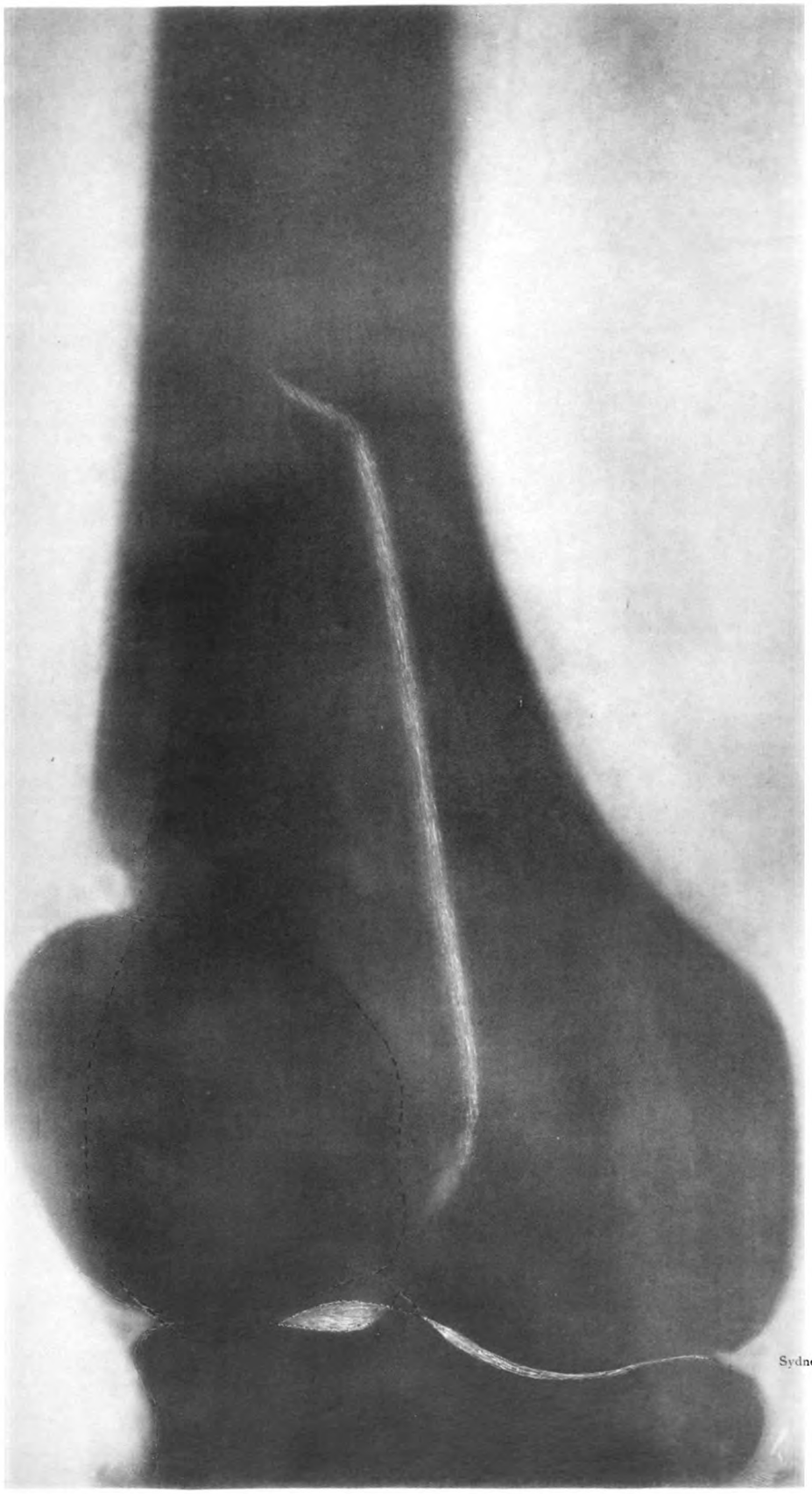

Sydney Rowland, Skiag.

LVII

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SKIAGRAM OF FRACTURE OF FEMUR EXTENDING INTO KNEE JOINT.

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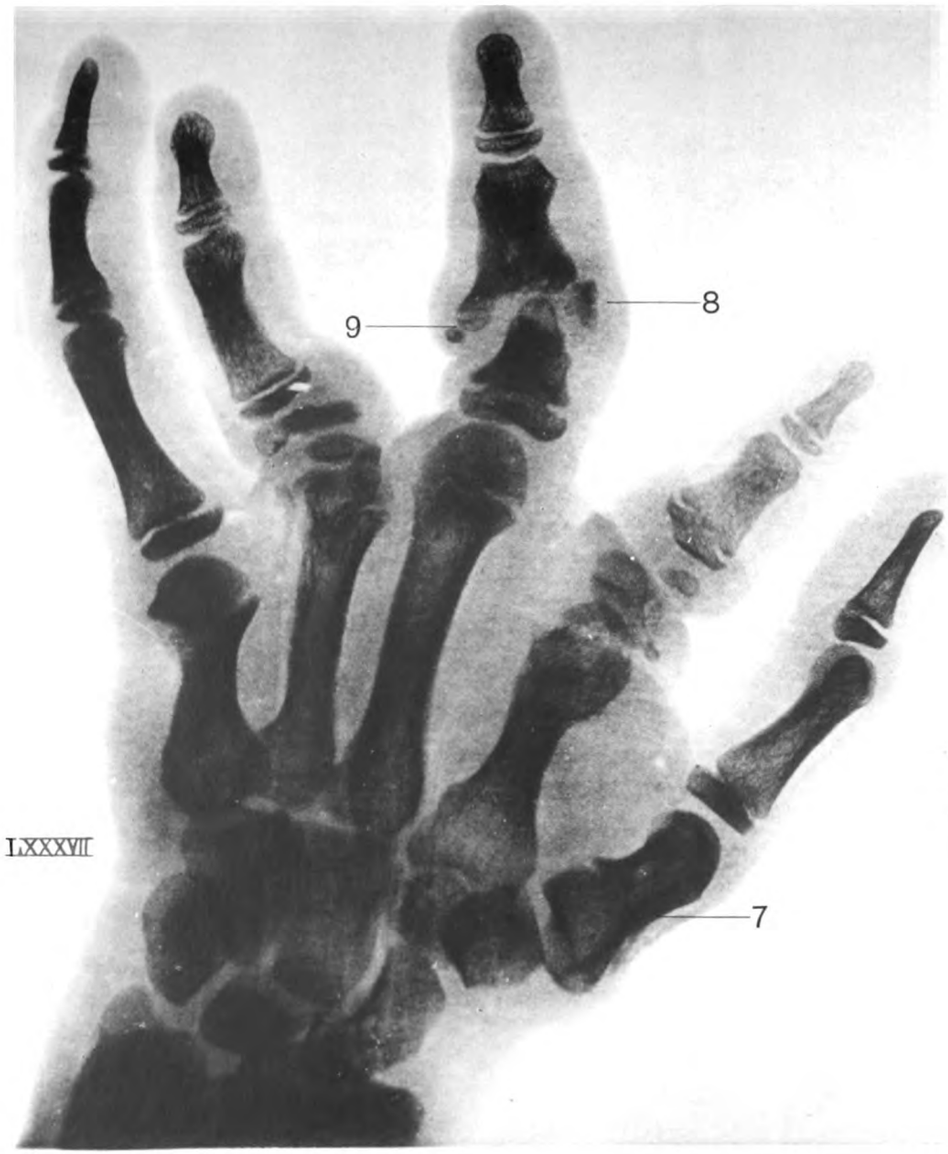

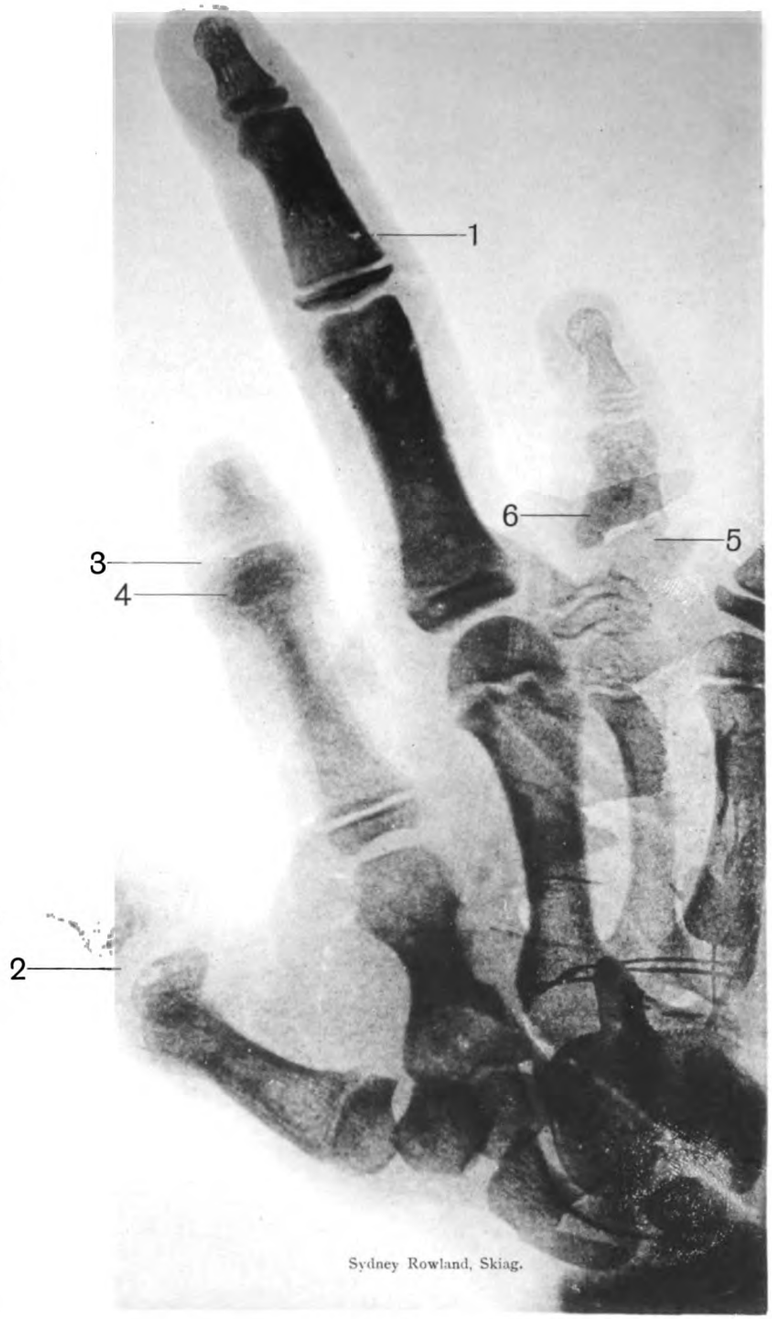

LXXXVII

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DEFORMITY OF HAND.

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LXXXVIII

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DEFORMITY OF FOOT.

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second phalanx, the stunted and deformed diaphysis of which last is thick with a very oblique base (6).

On the right side the thumb, save for a very thick and short metacarpal bone (7), is normal. The same may be said of the little finger. The first phalanges of index, middle, and ring fingers are deformed and truncated. The epiphysial end can be made out in all. The shafts are either wanting, are truncated, or are so thin as to be recognizable only by position—not at all by shape. The form of the second phalanx of the middle finger appears like a further development of the condition found on the same phalanx of the right ring finger. It appears that the dark blots, marked 8 and 9, are the displaced and barely-developed epiphyses of the second phalanx. If so, it had two ossific centres—one at each margin, forming a sort of socket for the conical end of the first phalanx to play in.

The feet exhibit very analogous conditions, complicated by pressure on the soft unformed bones, of badly-fitting boots. The right foot more nearly resembles the left hand—in it the second metatarsal bone and phalanges* are well formed and normal; therefore it projects far beyond all the other toes. The metatarsal bone of the great toe has a short truncated shaft. On the inner side of it are two dark blots, marked 10 and 11. The former appears to be the epiphysis of the metatarsal bone; the latter that of the first phalanx. Here, too, as at 8 and 9, a sort of interlocking false joint is formed. The phalanges of the three outer toes, especially of the third, are imperfect, and either in great part incomplete or still cartilaginous. Their inclination inwards is due to the pressure of boots, to which also the cramping and overlapping of the metatarsal bases may be ascribed. The left foot is more normal; the first metatarsal diaphysis, being short and thick, gives to the second toe a fallacious appearance of abnormal length. The bend inwards of the outer three toes is due to external pressure.

* It should be remembered that the second toe is in certain ways the homologue of the middle finger—for instance, in the insertion of the inter-ossei.

Note on the Skiagram.—The first impression obtained on glancing at these two plates is that the skiagram is a very poor one. This is not, however, the reason for the apparent indistinctness of the picture, for if the hand on Plate XI. be inspected, it will be seen that the long second finger of the left hand is quite distinct, while the adjoining ones are more or less indistinct. The explanation of this varying distinctness is probably to be found in the deficient ossification of certain bones: that is to say, in the inadequate deposition of calcareous matter in most of the bones, and therefore a too facile passage of the X rays. S. R.

ANSWERS TO CORRESPONDENTS.

J. L.—The minimum spark required is two inches. It is necessary to have fully this length of spark, hence a coil giving a nominal three inches is the smallest you ought to have.

T. L. P.—Wrap the plates in black paper. The variety known as needle paper is very good. Use the most rapid plates you can get, and do not be afraid to push development to the utmost. There being in most cases no half tones to worry about, development is much simpler than in the case of ordinary photographic work.

IGNORAMUS.—You may know your focus tube is working correctly when one-half is fluorescing a yellowish green and the other half remains comparatively dark. After prolonged use, and especially if the platinum plate has been overheated, the vacuum is apt to increase. In this case the tube may be restored by heating over a spirit lamp until as hot as the hand can bear. Be careful to keep the tube revolving when heating, so as to equalize the temperature.

RAND.—Never work a coil from an accumulator without interposing a resistance. The object of this is to prevent short circuiting should the interruptor stick. Without a resistance under these circumstances two great risks are run. Firstly, the primary of the coil may be heated to such an extent as to melt the insulation; and, secondly, the accumulator may be seriously injured (buckled) by so rapid a discharge.

W. R. W.—In my experience the best way to manage a coil during an exposure is so to arrange the rapidity of interruptions (by altering the tension in the spring) as to obtain the most brilliant fluorescence of the tube with the most rapid make and break. Given sufficient potential to "get through" the vacuum, further effect depends on rapidity of interruption, and not on increased potential —at least, this is my experience.

KATHODE.—See answer to "Rand."

J. N.—The object to be skiagraphed should be placed as near the plate as possible. Treat the whole matter as a shadow and you cannot go wrong.

S. DE V. S.—Iodoform is very opaque to X rays. In cases that have been dressed with Iodoform, or injected with Iodoform emulsion, be careful to eliminate opacities on the plate due to this substance. Cases are recorded in which particles of Iodoform have been mistaken for foreign bodies, and even led to unnecessary incisions.

W. D. R.—As yet no substance has been found to give better results than Potassium Platino Cyanide. Its only drawback is its expense. Grind the crystals to powder, mix with gum arabic to form a thick paste, and spread as evenly as you can on black cardboard. To give the best results the salt must be fully hydrated; to ensure this, spray the screen from time to time with distilled water. It is essential to use plenty of crystals, and to have a thick layer.

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— of —

SKIAGRAPHY.

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PLATE XIII. Fig. 1 and Fig. 2.

SKIAGRAMS OF FRACTURE OF THE OLECRANON TREATED BY SUTURING WITH WIRE.

By ALBERT E. MORISON, M.B., F.R.C.S., C.M., Hon. Visiting Medical Officer, Hartlepools Hospital.

R. L., aged sixteen, consulted me on June 16th, 1896, complaining of weakness of the arm and pain at the back of the elbow on movement. He gave the following history:—On January 19th, while walking, he tripped in a cart rut and fell on the tip of his right elbow. Two hours after he went to a doctor, who told him the bone was broken and set it, applying splints. These he wore till January 30th, the forearm being kept at right angles to the upper arm. As it still continued weak and painful, on February 3rd he went to a bone setter, and he applied strapping to the limb. His arm did not improve, it still was very weak, and he had severe pain at the back of the elbow on movement.

Present State.—The posterior part of the upper arm is very much smaller than the opposite arm, owing to atrophy of the triceps. Movement in the direction of full flexion and extension is painful, especially the latter, and he is unable to straighten his forearm on the upper arm by about 25°.

On examining the elbow, there is a painful spot over the olecranon (Fig. 1). The process is freely movable, and separated from the ulna below by three-quarters of an inch in full extension, and one and a half inches in full flexion. A fibrous band can be felt joining it to the ulna.

Operation.—The limb was previously thoroughly purified and made aseptic.

July 23rd: Chloroform having been administered, an elastic

bandage was applied to the arm high up to make it evascular. A longitudinal incision about two and a-half inches long was made over the back of the elbow joint. The space between the olecranon and the ulna was filled with dense fibrous tissue. This was divided and removed, the elbow joint being thus opened. The olecranon was next fixed between the finger and thumb, and a thin slice removed to give a raw osseous surface. The upper end of the ulna was treated in a similar manner. The two ends of bone were then drilled obliquely, and two strands of thin silver wire passed through the holes, and on being tightened the two surfaces of bone came into good apposition. The cavity of the joint was washed out with weak corrosive lotion, and the skin wound closed with silk sutures, two sutures of the same material being passed through the periosteum. Antiseptic dressings were applied, and the arm bandaged to a straight anterior splint.

Progress and After-Treatment.—Except for sickness continuing eighteen hours patient had no inconvenience. The highest temperature was 99·6 on the evening after the operation, and the patient was allowed up on the second day.

August 1st: Wound dressed, skin sutures removed, passive movement commenced.

7th: Can get the arm almost to a right angle. Splint removed and a sling used to keep the arm at an angle of 135°.

14th: Union is apparently perfectly firm, there being no lateral movement to be obtained between the fragments. Flexion is gradually increased each day until complete. He is now encouraged to move the arm himself.

September 24th: Movement is apparently perfect, though the arm is still weak, and there is still atrophy of the triceps. This, however, is improving. The olecranon feels firmly united. Patient was sent to Messrs. Brady and Martin, of Newcastle-on-Tyne, to have the arm skiagraphed. The skiagram (Fig. 2) shows that there is still a slight space between the fragments. A point of interest is whether this space is filled in with fibrous tissue or with cartilaginous matrix which will eventually become bone. I am indebted to Messrs. Brady

and Martin for the excellent skiagrams which illustrate the case. Fig. 1 was taken on July 10th, before, and Fig. 2 on September 24th, two months after the operation.

PLATE XIV. Fig. 1.

SKIAGRAM OF FRACTURE OF LOWER END OF HUMERUS, WITH SEPARATION OF THE EXTERNAL CONDYLE.

By HUGH M'LEAN, F.R.C.S.Edin.

R. T., aged seven years, fell on 8th September from a height of about five feet, getting his arm caught between two horizontal rails in the fall. When seen, the arm was so much swollen that the real nature and extent of the injury could not be made out. These, however, were clearly seen a few days afterwards, by means of the skiagrams, to be limited to fracture of the lower end of the humerus, with separation of the external condyle. The final result has not been seen, as the case is still under treatment.

PLATE XIV. Fig. 2.

SKIAGRAM OF HIP JOINT DISEASE.

By JOHN MACINTYRE, M.D., Glasgow.

Represents a case of old-standing hip-joint disease in a young lad, the normal and diseased hips being both seen.

PLATE XV.

SKIAGRAM OF SIX TOES IN EACH FOOT.

By JAMES MACKENZIE DAVIDSON, M.D.

The patient was a young lady, aged twenty, who suffered inconvenience from the extra breadth of her feet, and her surgeon decided to remove the supernumerary toes. He informs me that the skiagram enabled him to operate with much greater precision than if he had not had it to guide him.

PLATE XVI.

SKIAGRAM OF A DOUBLE MONSTER.

By J. LYNN THOMAS, F.R.C.S. Eng., Assistant Surgeon to the Cardiff Infirmary.

The specimen from which the skiagram is taken belongs to my friend Prof. Hughes, of University College, Cardiff, and is that of a double monster in which the two breeches and lower extremities are quite separate.

The duplication commences inferiorly and terminates at the umbilicus, and there is only *one* umbilical cord and one placenta. From the umbilicus upwards towards the head there is fusion of the parts, so that there is only one apparent neck and skull. The four upper limbs are well developed, and one notices the complete absence of ossification in the carpus; whilst the metacarpi and phalangeal diaphyses are osseous.

It shows two faces, one of which is perfectly formed, and the other is incompletely developed and represented only by a pair of ears fused together.

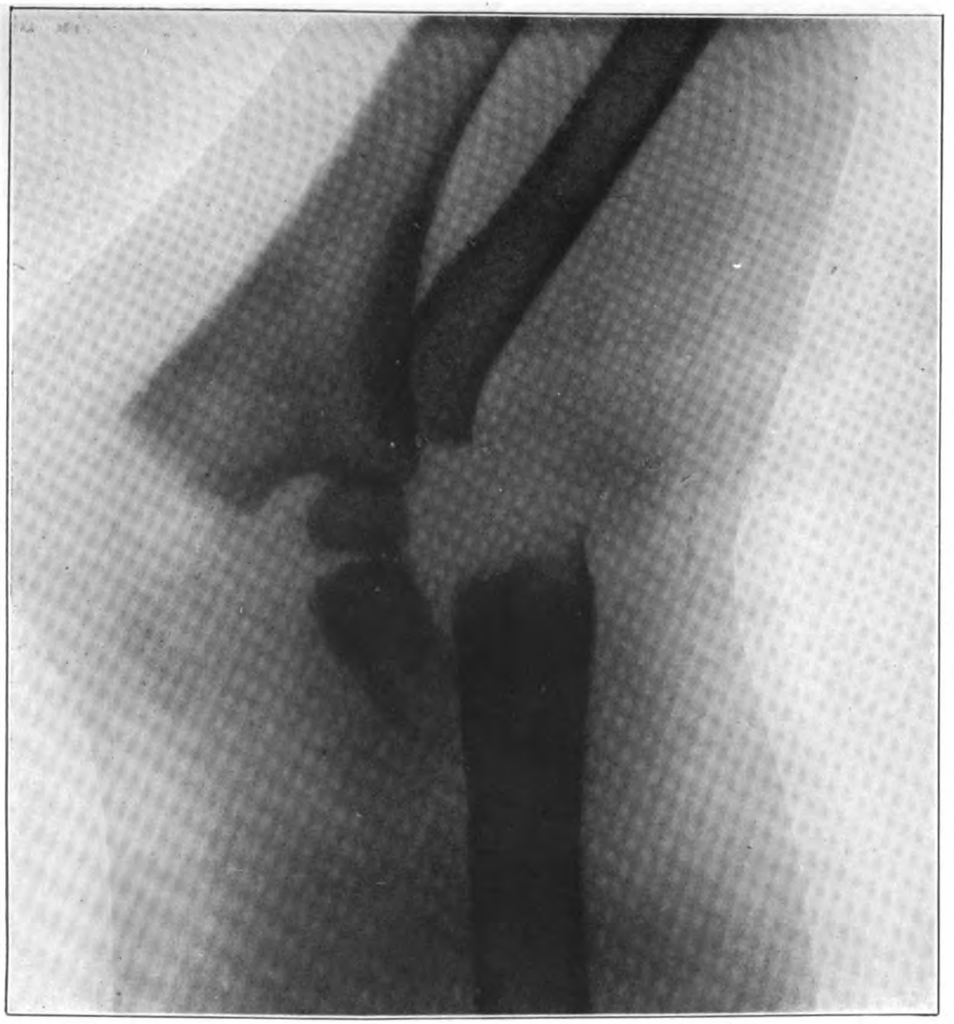
(*Copyright.*) FIG. 1.

(*Copyright.*) FIG. 2.

SKIAGRAMS OF FRACTURE OF THE OLECRANON, TREATED BY SUTURING WITH WIRE.

(*By ALBERT E. MORISON, M.B., F.R.C.S., etc., Hartlepool.*)

PLATE XIII.



(*Copyright.*) FIG. 1.

SKIAGRAM OF FRACTURE OF LOWER END OF HUMERUS.

(*By HUGH McLEAN, F.R.C.S., Edinb.*)

(*Copyright.*) FIG. 2.

SKIAGRAM OF HIP JOINT DISEASE.

(*By JOHN MACINTYRE, M.D., Glasgow.*

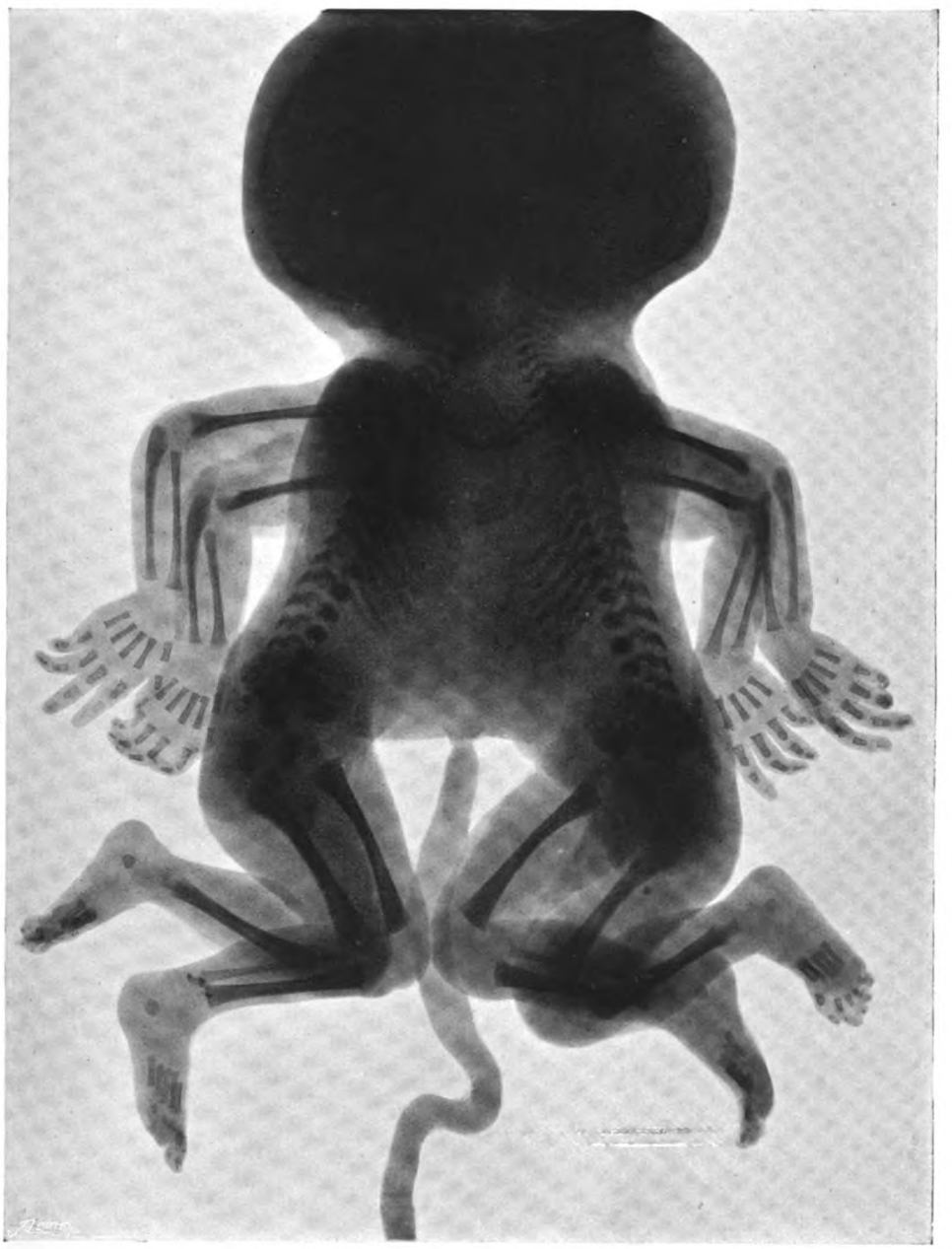
(*Copyright.*)

SKIAGRAM OF SIX TOES IN EACH FOOT.

(*By JAMES MACKENZIE DAVIDSON, M.D., Aberdeen.*)

PLATE XV.

(*Archives of Clinical Skiagraphy.*)



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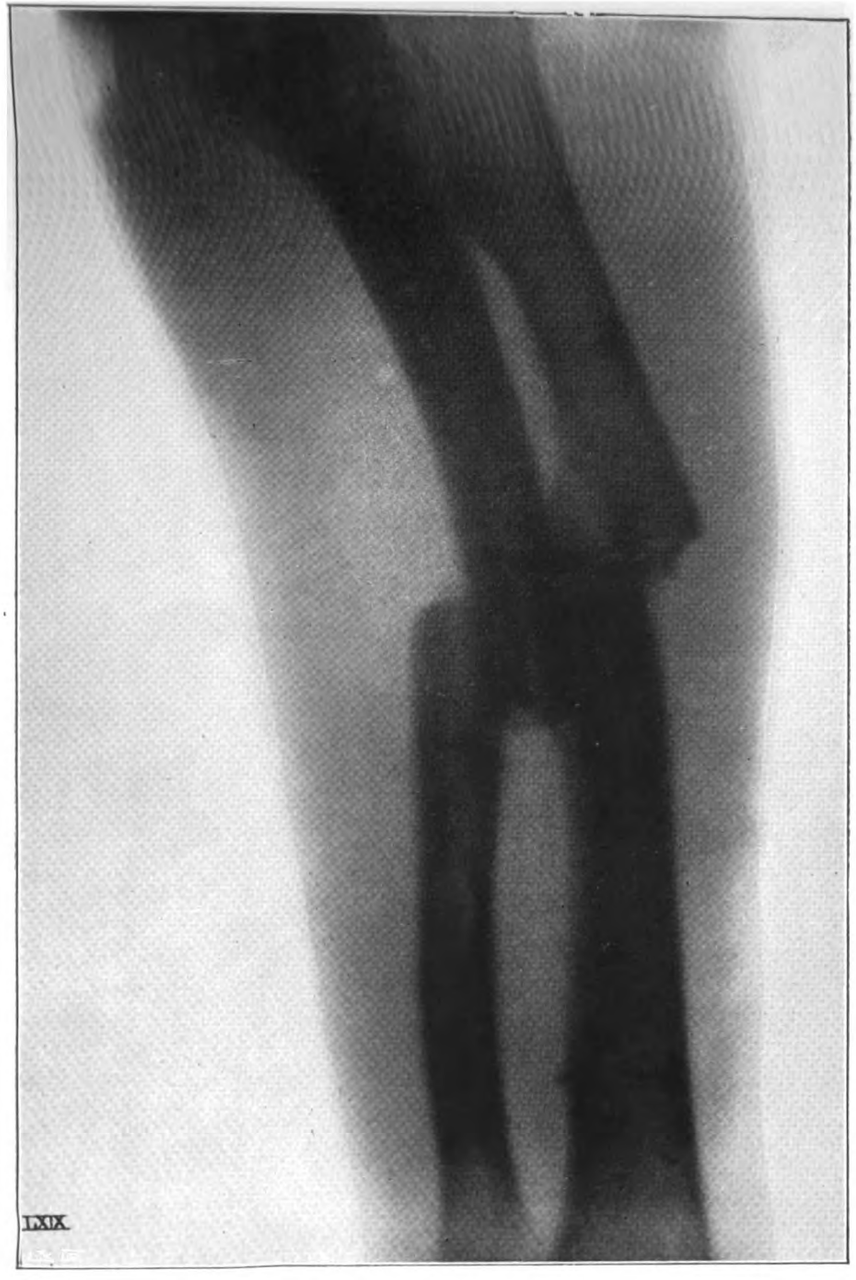
SKIAGRAM OF A DOUBLE MONSTER.

(*By J. LYNN THOMAS, F.R.C.S., Cardiff.*)

PLATE XVI.

(*Archives of Clinical Skiagraphy.*)



(*Copyright.*) FIG 1.

SKIAGRAM OF UNUNITED FRACTURE OF BOTH BONES OF THE FOREARM BEFORE UNION.

(*Copyright.*) FIG. 2.

SKIAGRAM OF UNUNITED FRACTURE OF BOTH BONES OF THE FOREARM AFTER UNION.

(*By SYDNEY ROWLAND, B.A., Camb., London.*)

PLATE XVII.

...chives of Clinical Skiagraphy.)

(*Copyright.*)

SKIAGRAM OF THE SOFT AND THE HARD TISSUES.

(*By JOHN MACINTYRE, M.D., Glasgow.*)

PLATE XVIII.

(*Archives of Clinical Skiagraphy.*)

The skiagram shows two bases cranii, and two distinct columns of cervical vertebræ with their anterior surfaces facing each other; the curves of the vertebral columns are normal, and the relative sizes of each vertebra are those of the normal fœtus. I would draw attention to the curved arch between the vertebræ of the cervical region with a small gap in the middle; it is that of the inferior maxilla seen *through* the neck, the monster being on its face during skiagraphing. I have a skiagram of this monster taken with the face upwards, and it shows no trace of the inferior maxilla, as the head was thrown well back. There are but few points I would venture to draw attention to, as they are fairly distinct and of skiagraphical interest.

The lower extremities of the right monster show well the folds of the *overlapping* limbs, and I think it is a common phenomenon for folds or twists to be better marked when some other X-rays semitranslucent substance is over them. The right limb of the right monster is also apparently narrower or thinner than the left one, on account of its being nearer the film than the left one, in accordance with the well-known law of shadow formation. The ossific centre of the os calcis is conspicuous by its loneliness in the tarsi. The comparative lengths of the diaphyses of the limb bones are marked.

The four clavicles are well shown, but there is no trace of the sterna.

Prof. Hughes intends giving a fuller description of this monster before one of the learned societies next winter.

PLATE XVII. Fig. 1 and Fig. 2.

SKIAGRAMS OF UNUNITED FRACTURE OF BOTH BONES OF THE FOREARM BEFORE AND AFTER UNION BY WIRING.

A gentleman was riding in the park, when his horse bolted and carried him against a tree. In order to save his face he put up his arm, which thus came in violent contact with the tree trunk. He was

carried unconscious to St. George's Hospital, where the arm was put on a splint. On recovering consciousness the patient returned home. Some weeks later massage was carried out, and three months later it was clear that no union had taken place. The patient then consulted Mr. Bland Sutton, who advised resection of the broken ends of the bone. The forearm was skiagraphed by Mr. Sydney Rowland, as shown in plate (Fig. 1). The seats of fracture in the radius and ulna were exposed by lateral incisions, and a portion of bone removed from each fragment. The opposed ends of the ulna were secured in position by a loop of silver wire. An attempt was made to wire the ends of the radius, but the osseous tissue was too fragile to bear the drill, so the ends were brought into position and maintained in apposition by splint and bandages. Three weeks later the forearm was re-skiagraphed, and the improved relations of the fragments are shown in Fig. 2.

PLATE XVIII.

SKIAGRAPHY OF THE SOFT AND THE HARD TISSUES.

By JOHN MACINTYRE, M.D.

The advantages of the new rays have been fully demonstrated in the hard tissues, and there can be no doubt they now have, and will always have, a distinct place in the diagnosis of the pathology of the osseous structures. With improvements in our apparatus the extremities are now comparatively easily demonstrated, but the regions of the skull and pelvis still offer a little difficulty in stout people. So much progress has, however, been made with the skeleton that physicians have naturally turned their attention to the photography of the soft tissues. During my earliest experiments I was impressed with the fact that in the lower animals the viscera could often be determined on a photographic plate with such definition as to give hope that in man similar results would ultimately be obtained. As far back as March of this year, I began a series of experi-

ments with a view of determining how far the heart could be photographed.

In Plate XVIII., a reproduction of the first photograph of the heart attempted will be seen. There the outline of the organ in its contained sac is perfectly distinct. Below it one can see a curve representing the diaphragm, surrounding it there are the ribs, and in the neck there is an indication of the large blood-vessels. The natural suggestion to those engaged in this study was, that if the bones of the extremities were to be photographed with a given apparatus in a certain time, less exposure might enable us to catch the soft tissues before they disappeared. Experience, however, did not bear out this idea, and instead of less force being required it was found necessary to obtain the greatest number of X rays possible with the most powerful apparatus at my disposal for the following reasons: In the first place, to obtain sharp shadows it was necessary to remove the tube a considerable distance from the object. Again, an object like the heart is deeply seated, and, therefore, there is moreover a considerable amount of tissue-fasciæ and muscle to pass through. Further, owing to movement, the exposure required to be as short as possible. Pursuing this line I gradually increased the ampères of current from the main, used a mercury interrupter, and step by step worked up so much pressure on the tubes that the glass would not stand the molecular strain. Personally, I found it of less value to judge of my current by the length of spark. One must remember that the coil is simply a transformer of energy, and that there must be a definite relationship between the amount of energy which is passing into the coil and the amount of X rays got from the tube. There are many factors to be considered between these two points, not the least important of which is the interrupter, because the sharpness of the make and break, the number of vibrations per second, as well as other things, tend to modify the force at our disposal. I find that, even with a current which registers twenty ampères across the terminals and passing through the coil directly the interruptions by means of the spring begin, the current falls to three or four ampères, as measured by

Lord Kelvin's ampère gauge. When the mercury interrupter is used it is seen that seven, eight, or even ten ampères can be registered. In testing the rapidity of exposure I was able by this means to photograph the bones of the hand distinctly with a single flash of the mercury, make and break. Ten such flashes gave me one of the finest negatives of the bones of the hand which I possess. By these means photographs of many soft tissues can be obtained, and I need hardly point out that such high currents test the tubes severely, and as a rule, I do not use the strongest currents, unless there be some good reason for doing so, preferring to give a longer exposure. I have photographed a number of pathological changes in the cardiac area, one being the case of a child with pneumonia, in which there was an enlarged right ventricle, in another, hypertrophy of both ventricles in an adult; further, a considerable number of normal conditions in children and adults have also been registered with a view to comparison of the size in different conditions before and after exercise.

PLATE XIX. (*a*)

By GERARD SMITH, M.R.C.S.

A lad of seventeen, with advanced and permanent talipes plantaris and calcaneus of left foot. The skiagram shows well the altered form of the os calcis and its relations to the astragalus, and also the altered relative positions of the scaphoid and astragalus. The special interest of the case is in the inward rotation of the foot (a comparatively recent change), the foot tending towards varus; and the abnormal position of the outer and inner malleoli with the astragalus is striking (the foot was most carefully placed on the plate, but the tube parallel, and over and opposite the outer aspect of ankle joint).

The patient sought relief for a new symptom—great pain precisely at the spot marked X, the astragalo-scaphoid articulation, this pain being caused by the weight of the body pressing the inner malleolus against the articulation, owing to the tendency to varus.

PLATE XIX. (*b*)

DISLOCATION OF ELBOW—SIX WEEKS' DURATION.

By WM. JAS. FLEMING, M.D., Glasgow.

PLATE XX. (*a*)

MULTIPLE OSTEOMA.

By W. D. HEDLEY M.D., M.R.C.S., London.

PLATE XX. (*b*)

FRACTURE OF RADIUS AND ULNA, WITH DISLOCATION OF RADIUS BACKWARDS.

By W. D. HEDLEY, M.D., M.R.C.S., London.

PLATE XXI. (*Ten minutes' exposure.*)

CONGENITAL DISLOCATION OF LEFT HIP.

By J. L. THOMAS, F.R.C.S., Cardiff.

Beatrice Kennedy, aged seven years. It shows well the cotyloid cavity, the head and neck of femur, and is a suitable case for reposition of head of femur in the acetabulum ; the conditions which Brodhurst considers favourable to operative interference are present.

SKIAGRAPHY IN ZOOLOGY.

By R. NORRIS WOLFENDEN, B.A., M.D. Cantab.

The editor of the ARCHIVES OF SKIAGRAPHY having kindly extended the scope of his publication to matters of other than clinical interest connected with radiography, I am allowed the opportunity of publishing through this medium the results obtained by submitting my zoological specimens to the X rays. These specimens were obtained by me while dredging in the Scapa Flow, Orkney, during the autumn months of 1896, and I propose to publish a number of plates dealing

with marine specimens — echinodermata, mollusca, crustacea, and British fishes. The results obtained have generally been very beautiful, and, I think, instructive. I have to thank Dr. Macintyre, of Glasgow, for kindly placing his laboratory and apparatus at my disposal, most of the work to be published having been conducted there in February, 1897, my specimens, preserved in spirit, having been brought south from the Orkney Islands, where they were obtained.

The ordinary spring on the induction coil was employed for some, but most were photographed with the mercury interrupter, with exposures varying from one to five minutes, and it was found that with slow interruptions of an average of five per second, the most beautiful results were obtained, with very much shorter exposures than with the ordinary spring. The tubes used were Watson's Penetrator and Palladium, Newton's, and Baird and Tatlock's (of Glasgow), all equally good.

PLATE XXII.

HOMARUS VULGARIS (THE LOBSTER).

This represents the skiagram of the common lobster, taken from above, and with an exposure of three minutes, using a ten-inch spark coil and Watson's new Palladium tube.

The anatomy of the animal is so fully described in the text-books of zoology that it seems needless to enter into any description of so common a natural history type.

The segmentation of the body is well indicated, as are the various parts of the limbs. This specimen was a male, the "claspers" of the fifteenth segment being clearly discernible.

The globular stomach, which occupies the greater part of the head, is indicated, as also is the heart and pericardial sinus.

PLATE XXIII.

CANCER PAGURUS (THE EDIBLE CRAB).

By R. NORRIS WOLFENDEN, B.A., M.D. Cantab., London.

This animal was submitted to the same exposure as the lobster figured in the previous plate.

The anatomy of this animal is also fully described in the text-books, and in all essential points it resembles that of the lobster. The segmentation of the abdomen is beautifully distinct. The duplicate impression of some of the ambulatory limbs was caused by the animal (which was photographed while living) having slightly shifted the legs while under exposure.

PLATE XXIV. (*a*) AND (*b*)

THE HERMIT CRAB.

By R. NORRIS WOLFENDEN, B.A., M.D. Cantab., London.

Figure (*a*) represents the common hermit crab, which had made its home in a whelk shell, and was dredged by me from a depth of twenty fathoms. The soft body, general absence of abdominal appendages, and rudimentary appendages at the end of the abdomen, by which the animal maintains his position in the shell, are distinctly seen. One chela is greatly larger than the other, and is commonly used by the animal as a stopper to the shell entrance.

In figure (*b*) is shown a radiogram through a small sponge dredged from a depth of twenty fathoms in the Scapa Flow, Orkney, in which a hermit crab had taken his residence. The radiogram revealed the presence of a small shell embedded in the sponge.

(*Copyright.*)

DISLOCATION OF ELBOW.

(*By WILLIAM JAMES FLEMING, M.D., etc., Glasgow.*)

PLATE XIX. (*b*).

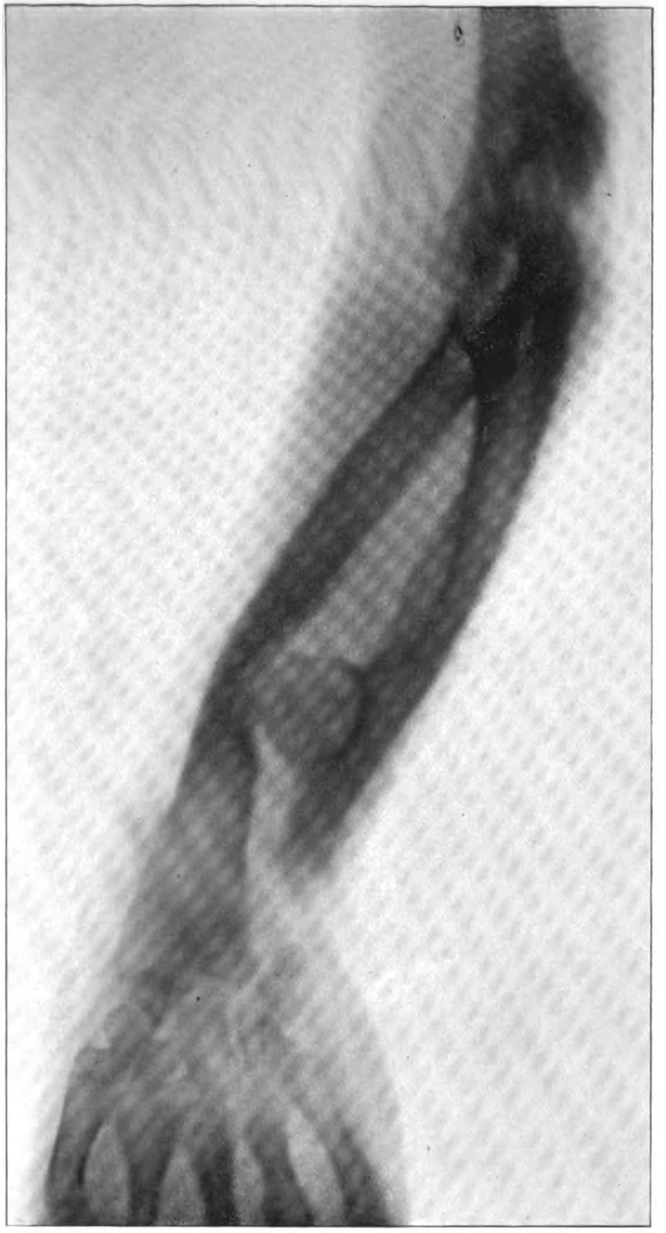
(*Copyright.*)

TALIPES PLANTARIS AND CALCANEUS.

(*By GERARD SMITH, M.R.C.S., London.*)

PLATE XIX. (*a*).

(*Archives of Skiagraphy.*)



(*Copyright.*)

MULTIPLE OSTEOMA.

(*By W. D. HEDLEY, M.D., M.R.C.S., London.*)

PLATE XX. (*a*).

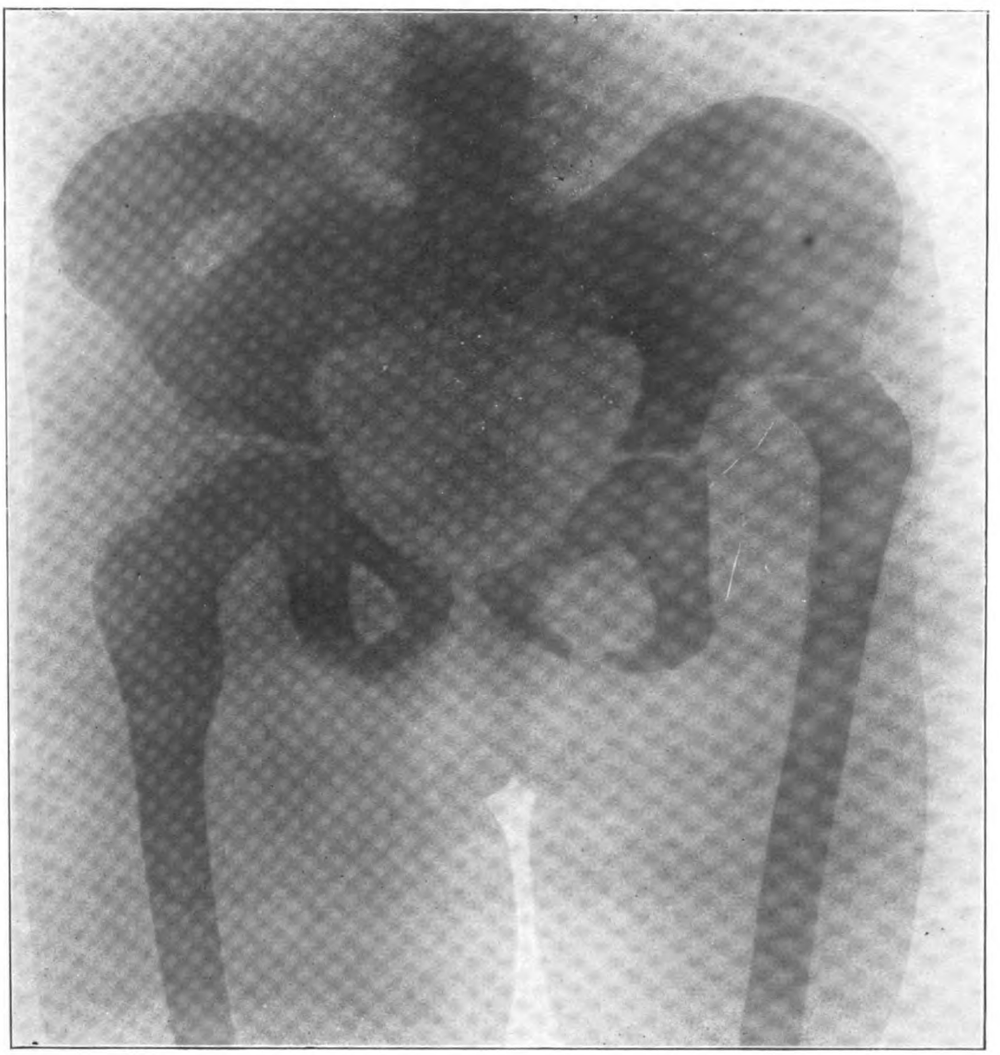
(*Archives of Skiography.*)

(*Copyright.*)

FRACTURE OF RADIUS AND ULNA, WITH DISLOCATION OF RADIUS BACKWARDS.

(*By W. D. HEDLEY, M.D., M.R.C.S., London.*

PLATE XX. (*b*).



(*Copyright.*)

CONGENITAL DISLOCATION OF THE LEFT HIP.

(*Ten minutes' exposure.*)

(*By J. L. THOMAS, F.R.C.S., Cardiff.*)

PLATE XXI.

(*Archives of Skiagraphy.*)

(*Copyright.*)

HOMARUS VULGARIS (THE LOBSTER).

(*By R. NORRIS WOLFENDEN, B.A., M.D., Cantab, London.*)

PLATE XXII.

(*Archives of Skiagraphy.*)

(*Copyright.*)

CANCER PAGURUS (THE EDIBLE CRAB).

(*By R. NORRIS WOLFENDEN, B.A., M.D., Cantab, London.*)

PLATE XXIII.

(*Archives of Skiagraphy.*)

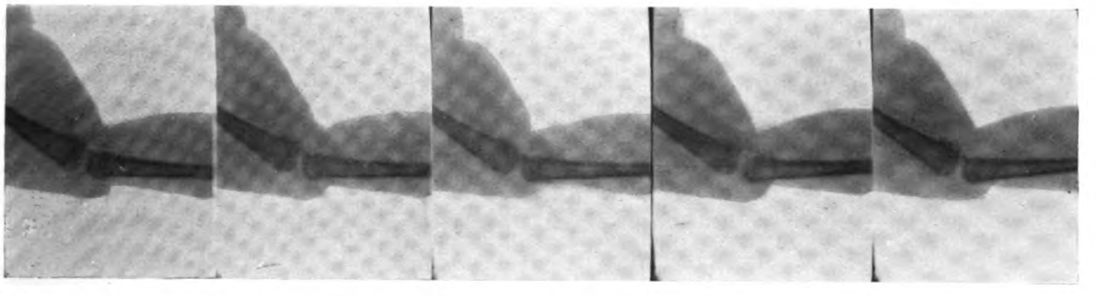
Fig. (*a*).

Fig. (*b*).

THE HERMIT CRAB.

(*By R. NORRIS WOLFENDEN, B.A., M.D., Cantab, London.*)

Fig. (*c*).



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X RAY RECORDS FOR THE CINEMATOGRAPH.

FROG'S LEG.

(*By Dr. JOHN MACINTYRE, Glasgow.*)

Plate XXIV.

(*Archives of Skiagraphy.*)

PLATE XXIV. (*c*)

X RAY RECORDS FOR THE CINEMATOGRAPH.

By Dr. JOHN MACINTYRE, of Glasgow.

Dr. Macintyre has for some time been experimenting on the best methods of obtaining rapid exposures with a view to recording the movements of organs within the body. Two methods have been adopted, one in which the shadow of the object, as seen upon the potassium platino-cyanide fluorescent screen, was photographed by means of the ordinary camera. This, however, was found to be too slow for the purpose. The other method was to allow the sensitive film to pass underneath the aperture in a case of thick lead covering the cinematograph. This opening corresponded to the size of the picture, and was covered with a piece of black paper, upon which the limb of an animal, say a frog, could be photographed. As yet, the movements must be slow, and consequently carried out by an artificial or slow anæsthesia. In the present state of our knowledge the former gives the more satisfactory results. Some months ago, Dr. Macintyre showed, by means of the mercury interrupter, that he could obtain instantaneous photographs of the bones of his fingers by a single flash of the tube, due to one vibration of the contact breaker. At a meeting of the Glasgow Philosophical Society recently, he was able to pass a film forty feet in length through the cinematograph ; the movements of the leg of a frog could clearly be seen when demonstrated on a magic lantern screen by means of the cinematograph.

A Skiagraphic Society has been formed in London by some of the leading men interested in the study of the X rays, both in their medical and general scientific application. That such a combination is greatly needed is well recognised by all those engaged in working at the subject. All interested are requested to communicate with D. Walsh, 5, Pump Court, Temple, E.C.

Vol. II.—No. 1.] JULY, 1897.

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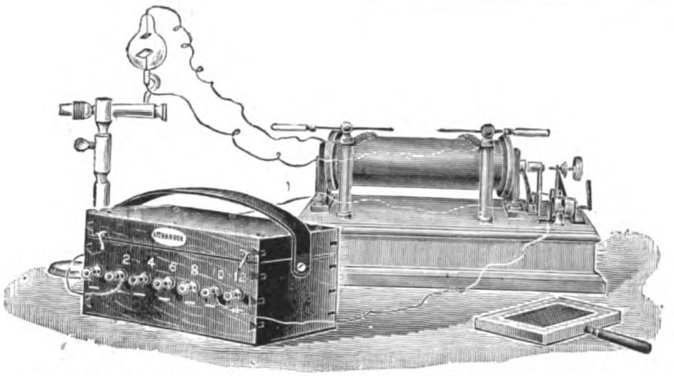

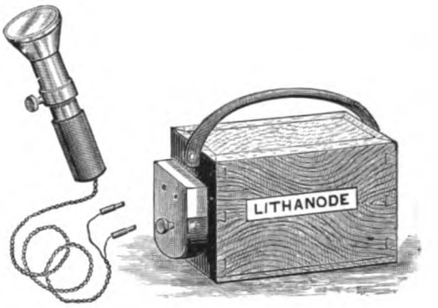

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THE EDITORS.

ON THE NATURE OF ROENTGEN'S RAYS.

By SILVANUS P. THOMPSON, D.Sc., F.R.S.

Though nineteen months have elapsed since Roentgen's discovery of the rays that bear his name was announced by him, we seem to be very little nearer to a true understanding of their real nature. The hypothesis to which Roentgen himself appeared to lean—namely, that they consist of longitudinal vibrations in the ether—has in no way been confirmed, and the general consensus of physicists is decidedly against any such supposition. But several other hypotheses have been put forward, no one of which can be said to be even approximately proved to be true, or can be accepted as inherently much more probable in its truth than the others. A brief glance at these hypotheses may be of some interest, though the arguments in favour of one or other of them are recondite, and are based upon points of physical science not easily handled in a popular way. The principal suggestions before the scientific world for discussion are three in number. The first, which is a corpuscular theory, attributes the Roentgen rays to a species of hyperatomic matter projected with great velocity, and capable of passing through the pores of ordinary solids. The second is that the Roentgen rays are simply an extreme case of ultra-violet light—that is to say, they consist of ordinary transverse vibrations in the ether, but differ from any known kind of light in having an excessively high frequency, and therefore an excessively short wave-length. The third hypothesis, that of Sir George Stokes, is that the Roentgen rays, though consisting of transverse vibrations of the ether, and, therefore, truly a species of light, differ from ordinary light in the circumstance that the waves, instead of consisting, as ordinary light does, of regular trains of wavelets—half a million or more, on the average, in each train—are solitary waves, each "train" consisting of but one or two wavelets at the most.

It will be noted that in both the last two hypotheses the rays are considered as transverse waves in the ether. If either of them is true, the velocity of the wave propagation should be the same as that of ordinary light. But this is an exceedingly difficult thing to measure when one is dealing with rays of this character. The experiments of Foucault and of Cornu for determining the velocity of ordinary light cease to be applicable to rays which can neither be sensibly reflected nor refracted. If these rays consist at all of waves—if they are propagated as a true

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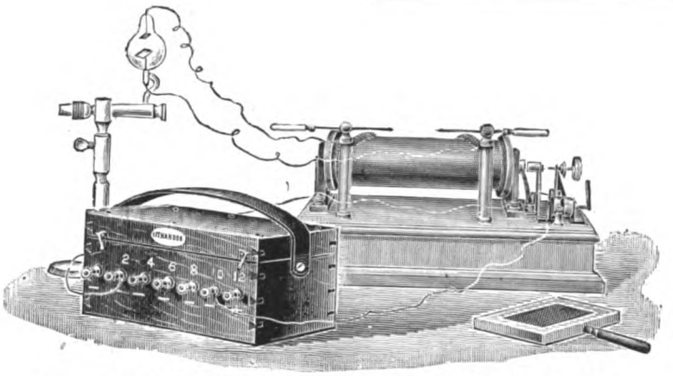

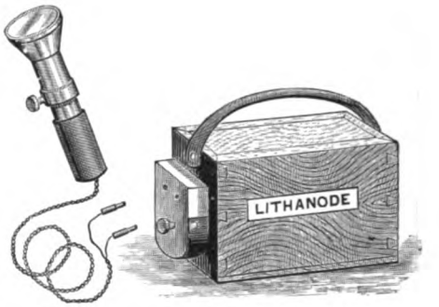

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It will be noted that in both the last two hypotheses the rays are considered as transverse waves in the ether. If either of them is true, the velocity of the wave propagation should be the same as that of ordinary light. But this is an exceedingly difficult thing to measure when one is dealing with rays of this character. The experiments of Foucault and of Cornu for determining the velocity of ordinary light cease to be applicable to rays which can neither be sensibly reflected nor refracted. If these rays consist at all of waves—if they are propagated as a true

wave-motion with that periodic recurrence in space and time which is characteristic of all wave-motions—then one would expect that it should be possible to measure their wave-lengths by one or other of the ordinary processes by which wave-lengths of light are measured in the physical laboratory. Most of these methods depend upon the principle of "interference" of waves, producing, where the overlapping waves meet and react on one another, the so-called "interference-fringes" or stripes of alternate light and darkness. These are well-known phenomena of physical optics; and the existence of such interference-fringes has been well established for the ordinary kinds of invisible light—that is to say, both for the ultra-violet or photographic waves, and for the larger infra-red or calorific waves, the respective wave-lengths of which are well known. It is, for example, now well known that the wave-lengths of all the visible kinds of light lie between a length of about thirty millionths of an inch for red light to about fifteen millionths of an inch for violet light, while the invisible ultra-violet waves have been tracked down by Schumann to about four millionths of an inch in length, and the invisible infra-red waves have been recognized by Rubens and Nichols up to a size of 944 millionths of an inch. But when one tries to apply the same processes to measure the wave-length of Roentgen light, on the supposition that it, too, has got a wave-length to be measured, innumerable difficulties crop up. In the first place, most of the interference methods require either reflection or refraction for the production of fringes, and are inadmissible for rays that cannot be sensibly reflected or refracted. The only chance is by having recourse to diffraction. If light issuing from a narrow slit is transmitted through a second slit, diffraction-fringes are produced; and from the widths of these fringes and the known widths and distances of the slits the wave-length can be calculated. This method has, indeed, been tried by quite a number of experimenters, but with wildly differing results. These are the principal figures given by the observers:—Kümmel finds 13·2 millionths of an inch, Sagnac 0·16 millionths of an inch, Fomm 0·056 millionths of an inch, Voller 0·08 millionths of an inch, and Wood about two millionths of an inch. Who shall decide when one observer finds them 160 times as large as another observes them? If one observer were to find an object to be as big as a halfpenny, while another, using the same method, measured it as thirteen feet in length, should we not say that there was something totally wrong about the method of measurement? Another observer, Dr. Precht, using other varieties of interference methods, finds results varying from 0·064 up to 3·42 millionths of an inch. So it seems very doubtful whether the notion described a year ago by Prof. Lodge as the one "surviving hypothesis" of the Roentgen rays—namely, that they were only ultra-violet waves of very minute wave-length—can be considered as in the slightest degree proven. If they are waves, why such utter disagreement about their wave-length? As to Stokes' hypothesis of solitary waves, it can neither be proved nor disproved by the failure to measure the wave-lengths, and it is the only hypothesis yet formed which gives any adequate reason for the curious lateral emission of the rays observed in focus tubes.

The ultra-corpuscular theory, which was in one form started by Tesla, and is in another form now put forward by Prof. J. J. Thomson, is a startling one. If in the phenomena of cathodic bombardment going on in the Crookes' tube, the atoms of ordinary matter can be pulverized into a still finer hyperatomic dust, capable of flying in straight lines through the pores of solid bodies, through the walls of the tube, through aluminium sheets, through solid diamonds, through several inches of wood or flesh, then we have a truly amazing set of phenomena to face. The old idea that by no kind of process known to science could any chemical "element" be resolved into anything but itself, or be transmitted into any other "element," must be held to be an idea henceforth of doubtful truth; and the genesis, or at least the exodus, of the elements must be admitted amongst the possibilities of science. It is not without significance that Sir William Crookes, the pioneer of high vacuum experimentation, and the originator of so many valuable speculations as to the ultimate constitution of matter, should from the first have given his adhesion to the hyperatomic theory of these rays.

Much remains to be done before any of these speculations can be put to final proof. If it were to be found that the metals when cooled in liquid air were (for the same mass) much more opaque to Roentgen rays than they are at ordinary temperatures, then, arguing from the electro-magnetic theory, according to which opacity depends upon the absorption of transverse vibrations in electrically conducting substances, there would be a powerful, an almost overwhelming, argument in favour of the wave theory. But this experiment has yet to be made.

THE ROENTGEN SOCIETY.

THE Society held its first General Meeting on June 3rd, in the rooms of the Medical Society, Chandos Street. Prof. SILVANUS THOMPSON occupied the chair. Laws were passed, Members enrolled, and Officers elected. The list of Executive is as follows:—

President: Prof. SILVANUS P. THOMPSON, D.Sc., F.R.S.

Vice-Presidents: Prof. FERRIER, F.R.S.; J. H. GLADSTONE, Ph.D., F.R.S.; JOHN MACINTYRE, M.B.; C. W. MANSELL MOULLIN, F.R.C.S.; FLETCHER MOULTON, Q.C., F.R.S.

Hon. Member: Prof. ROENTGEN.

Council: F. E. FENTON, F.R.C.S.; MACKENZIE DAVIDSON; J. E. GREENHILL; W. S. HEDLEY, M.D.; F. H. LOW, M.B.; T. MOORE, F.R.C.S.; SYDNEY ROWLAND; A. A. CAMPBELL SWINTON; W. WEBSTER, F.C.S.; NORRIS WOLFENDEN, M.D.; SNOWDEN WARD.

Treasurer: T. MOORE, F.R.C.S.

Secretary: DAVID WALSH, M.D.

The following are the rules adopted by the Society:—

1. *Name.*—That the name of the Society be "The Roentgen Society."

2. *Objects of the Society.*—That these be as follows:

(1) To discuss the Roentgen rays in their relation to medicine, the Arts, and Sciences.

(2) To discuss and exhibit apparatus and methods in connection with the rays.

(3) To hold periodical meetings for the reading of papers and discussions thereon; with exhibition of clinical cases, skiagrams, and all matters bearing on the Roentgen rays.

(4) To provide a museum, library, and Roentgen ray appliances.

(5) To publish transactions in a convenient form.

3. *Qualification of Members.*—That candidates for membership must have shown some scientific interest in the Roentgen rays.

4. *Election of Members.*—That candidates be balloted for at general meetings; notice of candidature to be announced at previous general meeting. One black ball in six to exclude.

5. *Election of Council.*—That the council be elected at the annual general meeting by majority of members. The list of names proposed for election to be sent to members at least a week before such election.

6. *Meetings.*—That the general meetings be held monthly, or at such convenient times as may be determined by the council, and that the council meet half-an-hour before general meetings, or at such other times as may be requisite. In addition, an annual general meeting to be held for address of president, election of officers and other business.

7. *Administration.*—That the administration consist of (*a*) president, to be elected annually (he may be re-elected, but may not hold office for two consecutive years); to be chosen so far as possible from the vice-presidents. (*b*) Vice-presidents (not exceeding six) to be chosen annually. (*c*) Council of twelve, to be elected annually, two to retire annually by ballot, and to be eligible for re-election for another year. (*d*) Honorary treasurer to be elected annually. (*e*) Honorary secretary, to hold office for two years, eligible for re-election. (*f*) President, vice-presidents, honorary treasurer, and honorary secretary to be *ex officio* members of council. (*g*) A certain number of honorary members to be chosen by council. (*h*) All cheques to be signed by treasurer and secretary. (*i*) A quorum of council to consist of five members, and a quorum of annual general meetings for business purposes to consist of twelve.

8. *Powers of Council.*—That these be: (*a*) To propose officers. (*b*) To purchase necessary books, apparatus, and other "plant" or appliances. (*c*) To expel or remove, by unanimous decision, Members guilty of unethical conduct, or more than twelve months in arrears with subscription. (*d*) To consider and approve names of candidates to be submitted for election at general meeting.

9. *Subscription.*—That the subscription be one guinea, payable annually in advance, or that a composition fee of fifteen guineas be taken as a life subscription.

10. *Making of Laws.*—That no new laws be made, and no existing law altered, without the consent of three-fourths of members present at a general meeting. Notice of such proposed alteration in addition, to be sent to members at least a month previously to their being laid before the general meeting for discussion.

The PRESIDENT made a few introductory remarks, of which the following report appeared in the "British Medical Journal" of June 12th:—

"He suggested a formal presidential address and an exhibition in the autumn. The position of their Society, he said, was between those devoted purely to medicine, to physics, and to photography. In themselves they focussed a number of interests provided for by no other existing bodies, such as, for instance, the Royal, the Physical, the Photographic Societies, or the Institution of Electrical Engineers. There was a very definite place to occupy and

function to fulfil. Some members would study the sources of the rays, others their application, some the induction coils, others the tubes and the various forms and adaptations of appliances. The Society would always gladly welcome the experiences of others, whether they dealt with the photographic, the luminescent, or the purely physical aspects of the subject. Among those interested in the application of the rays, the surgeons no doubt had the largest field in the detection of foreign bodies, of fractures, the diagnosis of soft tumours, and so on. Further applications were the botanical, in the study of seed pods and their contents, the mineralogical and metallurgical. Quite recently, Mr. C. T. Heycock, of Cambridge, by placing thin slices of alloys under the rays, had revealed their structure in a marvellous way. But quite apart from the sources and applications of the rays was the study of their physical nature. Many attempts to measure their wave-lengths had been made in European laboratories, but none of the results were so far trustworthy. Certain questions of intense interest to a few might still be asked. For instance, were these waves longitudinal or transverse? Were they waves at all? Were they flights of atoms or subatoms? Then there were a number of closely-allied phenomena of interest, chiefly as to the relation of the Roentgen rays to other rays, namely, those of the cathode of Lenard, and of the so-called 'discharge.' The rays of Becquerel, again, observed independently by the speaker himself, were given off in the dark week after week by certain substances, notably by metallic uranium. They penetrated like the X rays, but differed in being polarizable, and because they could be refracted and reflected. Other sources of light phenomena awaiting investigation were to be found in insects that gave out light, such as glowworms, fireflies, and some centipedes. The light of glowworms passes through aluminium and casts shadows. Then the light given off by rotten wood and stale fish might be expected to pass through aluminium and to take photographs. Phosphorus, when slowly oxidizing, threw off a light in the dark that could not pass through aluminium, but nevertheless penetrated celluloid and black cardboard and took photographs. There was, therefore, a wide field other than the surgical in which the members might labour. Into the Roentgen Society they would be glad to welcome any combination of workers. He hoped that their membership would extend to other countries, and that their published transactions, by furnishing solid contributions to scientific progress, might occupy an important place in the literature of science."

ROENTGEN RAYS.

A SURVEY, PRESENT AND RETROSPECTIVE.

W. S. HEDLEY, M.D.

THE origin and ancestry of the Roentgen ray is now an oft-told tale. The present writer must therefore be forgiven if, in the interests of historic completeness, he ventures to re-traverse some very familiar ground. When at Wurtzburg in December, 1895, Prof. Roentgen first announced his discovery, it came as a revelation to the world at large. But it was not so absolutely startling to the world of science. Many things had led up to it. Its lineage may be traced through the experiments of Wiedemann,* Lenard,† Goldstein,‡ Crookes and Hittorf,§ of Gassiot, Spottiswoode, Abria and Faraday ||—back to those fascinating electrical demonstrations of the Abbé Nollet that amused and amazed dilettanti *savants* of the French Court nearly a century and a half ago. According to Mons. Cornu, the first germ of the Roentgen ray is to be found in "the electric egg," an ovoid glass vessel with a variable vacuum, across which leaped the spark of the static machine. As the vacuum altered, so were the phenomena seen to change. Nearly a century later this experiment was repeated with electricity in new modalities. Faraday (1838) led the way to a systematic investigation of the phenomena that accompany electrical discharges through rarefied gases. In 1842, Abria of Boulogne, trying to discover how electricity travelled, passed the current of the induction coil through this same electric egg. What he saw were many of the now well-known phenomena of discharges in partial vacua. Everyone is familiar with the beautiful streams of purple light that proceed from the positive to the negative pole. As rarefaction increases, this purple light becomes a reddish purple spindle, starting from the positive pole, while at the negative pole there appears a thin blue-violet sheath; exhaustion rises higher, and the violet sheath becomes separated from the terminal by a small dark space. Pressure is decreased still further, and the reddish purple discharge from the positive pole becomes divided into striæ, and that ill-understood phenomenon, "stratification," is established. The purple light of the brush discharge has an extraordinary power of exciting fluorescence. Availing himself of this, Geissler

* "Zeitschrift für Electrochemie," No. 8, p. 159, 1895.

† "Annals of Wiedemann," Vol. LI., p. 225, 1894; Vol. LII., p. 23, 1894 Vol. LVI., p. 225, 1895.

‡ See "Monatsberichte" of Academy of Berlin, January 7th, 1880.

§ "Annals of Poggendorf," Vol. CXXXVI., 1869.

|| Faraday, "Experimental Researches," 13th Series, 1838.

of Bonn, constructed tubes with platinum wire electrodes, into which uranium glass, solutions of sulphate of quinine, and other substances were introduced, and to this day these "effect" tubes usually find a place upon the lecture table.

When very high degrees of vacuum are reached—*i.e.*, when pressure is reduced to (say) one millionth of an atmosphere or less—a series of phenomena appear absolutely differing from those noticed by Abria and the observers that immediately followed him. Now it is the phenomena of the negative pole that absorb attention. The positive or brush discharge is—if the expression be allowable—"nowhere." Certain of the high vacuum phenomena had already been studied by Hittorf (1865), Puling, and Goldstein; but it is from Sir William Crookes' investigations, brought before the Royal Institution and British Association (1879), that existing knowledge is chiefly derived. He showed that when the induced current of the Ruhmkorff coil passed through such vacua the appearance of stratification vanished, the glass became phosphorescent, and there emanated from the negative terminal an influence which he called "radiant matter." He considered that the molecules of the rarefied gas repulsed by the negative electricity bombarded the tube, and by this bombardment produced the phosphorescence—*i.e.*, excited the luminous vibration. He found that an aluminium screen stopped the stream of particles and produced a shadow, that a delicately balanced wheel was set in motion by the impact of this radiant matter, and that by employing as the negative terminal a saucer-shaped platinum mirror these projectiles could be made to converge, and platinum foil thus be brought to incandescence.*

In common with the fluorescence already described in lower vacua, this phosphorescence of bombardment is not due to light reflected, but to light emitted, owing to the molecules of the bodies being themselves excited into luminous vibration. But there is this distinction, that while fluorescence is usually an effect of ultra violet light-waves setting up in the fluorescent substance vibrations of another period, in the case of phosphorescence no proper light-rays are connected with the luminosity. It is the bombardment of molecules which excites the luminous vibrations.

* "It may be stated that the resistance of a gas to the electrical discharge diminishes as the pressure diminishes; but this does not go on indefinitely. At a certain very small pressure the resistance is at a minimum, and at the lowest pressure attainable the resistance is greater than at atmospheric pressure. Crookes arrived at the conclusion that across an absolute vacuum discharge would be impossible. He regards the residual particles of gas as the carriers of the discharge. When such particles are too numerous they hamper one another. When there are no carriers, nothing is carried."—*Everett.*

It need scarcely be said that Crookes' experiments excited the liveliest interest at the time, but "glory passes quickly," and for fifteen years the "Crookes' tube" shared the oblivion of the "electric egg."* It was Hertz who, in common with other German physicists, inclining to the belief that the discharge from the cathode was not electrified particles, but some kind of wave motion in the ether, drew the Crookes' tube from its retirement for further experimentation. Its second advent has proved more brilliant even than its first. Hertz found that the molecular bombardment passed through the aluminium screen if only the latter were thin enough. At this point Lenard (1894) took up the question, and showed that in these Crookes' tubes there was something more than a mere molecular bombardment. Placing in the wall of the tube a small window of aluminium, and taking advantage of the latter metal's transparency, he brought these cathode rays outside the tube. He found that they travelled in straight lines, that they could produce impressions on photographic plates, discharge electrified bodies, excite fluorescence, and even penetrate a sheet of black paper. In a remarkable communication made to the Electrochemical Society by M. Wiedemann, in June, 1895, there are described, as the result of passing electrical discharges through rarefied gases, special rays—"rays of discharge"—which do not pass through fluorspar, and upon which he had *not yet been able to show that the magnet had any influence.* The rays brought outside the tube by Lenard, were identified with the cathode rays in its interior, but now it is known that they were mixed with true Roentgen rays. It was Roentgen who differentiated the two. The Crookes' tube, covered with black paper, was put into action in a dark room; a fluorescent surface in its neighbourhood was found to be illuminated. Rays invisible to the eye had traversed the black paper, as was evidenced by the fluorescence of the screen; the "X ray" was discovered. And the experimenter laid his hand on a photographic plate covered with black paper and a Crookes' tube above the hand, and light passing through the softer tissues, a photograph appeared of the shadow of the bone. It was this experiment that directed public attention to the Roentgen ray, and laid the foundation of its popularity. "It was the hand that did it." Roentgen showed that this radiation was different from the "cathode ray." That the former could neither be sensibly reflected nor refracted, nor deflected by the magnet, or a strong magnetic field, nor polarized by any ordinary polarizing substance.

* Mons. Cornu.

Many attempts have been made to explain the difference in nature between Roentgen rays and ordinary light. The evidence seems tolerably conclusive that both are transversal vibrations in the ether. But there are two opinions as to the nature of the cathode rays. According to views largely held by German physicists the cathode rays are, like rays of light, "some process going on in the ether." In this country, on the other hand, the tendency is to regard them not as rays of light, but as streams of electrified molecules. Sir George Stokes, adopting this view, builds up a foundation for the assumption that these molecules projected against an anti-cathode cause ethereal disturbance in all directions. But, unlike the case of ordinary light, he postulates a succession of waves or pulsations, solitary and distinct.

There is yet another theory. This assumes the divisibility of the chemical atom, and suggests that even solids may be penetrated by flights of such sub-atoms hurled with tremendous velocity against them.

Prof. Roentgen sums up present knowledge as follows: 1. The radiation emitted by a discharge apparatus consists of a mixture of rays of different absorbability and intensity. 2. The composition of this mixture depends largely on the duration of the discharge current. 3. The rays absorbed by bodies vary for the different bodies. 4. Since the X ray has come into existence through the cathode rays, and both have qualities in common (for instance, photographic and electric effects, causation of fluorescence, absorbability, the degree of which depends largely on the density of the media, etc.), it seems likely that both phenomena are of the same nature.* Prof. Roentgen concludes by confirming G. Brandes' observation that X rays can in certain circumstances produce a sensation of light on the retina.

It need scarcely be added that more rays have recently been discovered. The rays of Becquerel, observed also independently by Prof. Silvanus Thompson, have been further experimented with by Dr. Russell.† It is found that not only uranium, but many ordinary substances, emit radiation, which, although invisible to the human eye, can penetrate opaque bodies. Such various substances as the section of a young larch tree, printers' ink, cardboard, lead and tin, when placed near a sensitive plate in a dark room leave a distinct impression on the plate. The Becquerel rays are "invisible light rays of an extremely ultra violet character, *i.e.*, transverse vibrations in the ether of extremely short period and wave length. It is now generally held that the Roentgen rays are ether waves of the same character but still higher frequency. The absence of sensible refraction, polarization, and regular reflection is exactly what would then occur. The waves are probably simply too small to be reflected from any polish at present attainable, or polarized by any ordinary structure in a sensible degree."*

The "Roentgen photograph" is the shadow of an object. Now the outline of a shadow is more distinct and the penumbra smaller—(1) The greater the distance of the luminant from the object. (2) The less the distance of the object from the surface upon which the shadow falls. (3) The smaller the source of the light. In the case of the radiograph the first of these distances cannot be pushed beyond a certain point owing to the increased length of the exposure that becomes necessary. (2) If a tissue of considerable thickness has to be traversed it is obviously impossible to decrease the second of these distances. Therefore (3) the most practicable course is to diminish the size of the source of the rays by concentrating the cathodic stream upon as small a surface as possible. This is effected by Jackson's focus tube, the greatest and almost the only great advance that has been made in practical radiography since the beginning. In this tube, now familiar to all, the cathode is a concave mirror, and the rays that emanate from it strike a flat platinum plate placed opposite to the cathode at an angle of about forty degrees. It is here, at "the anti-cathode," that the Roentgen ray takes origin, and hence it is directed to the wall of the tube which it penetrates. This tube is gradually beginning to undergo some modifications. The most promising of the latter is a method of adjusting the distance of the cathode from the anti-cathode according to the varying resistance of the tube and the nature of the work it is called upon to perform. In the form used by the present writer the cathode moves up and down by an arrangement similar to that used in adjusting the height of an ordinary candle shade. Of the two metal pieces, one carries the cathode and glides upon the other, and is enclosed in a bulbous glass tube, which extends up to the convexity of the cathode. Gentle tapping causes the metallic piece to which the cathode is attached to glide in either direction. The results are excellent, but the tubes, according to the present writer's experience, show a very considerable liability to crack. The anti-cathode is the ordinary platinum plate backed by a rather thick

* "Journal of the Royal Academy of Sciences."
† Paper read before the Royal Society, July, 1897.

* "The Induction Coil." By Lewis Wright. (Macmillan.)

piece of aluminium. The appearance of a focus tube when it is working well is fairly characteristic, but it should be routine practice to further test this point with the fluorescent screen. An examination with the latter is often sufficient for medical and surgical diagnosis, and saves further trouble when no permanent record is wanted.

Dr. J. Macintyre* claims to have sent the rays sixteen feet across a room and through a partition, and then examined by them the contents of a box in the next room; and M. Tesla states that his screen is effective (for an examination of the bones of the hand) "at distances of forty or fifty feet or even more" from the tube. For fluorescent screen work the room should be thoroughly darkened, and even the light from the focus tube and contact-breaker should be intercepted by means of black paper, or in some other way. If necessary to work in an undarkened room, the familiar device recently "exploited" by M. Seguy as the "lorgnette humaine" will be found useful.

Everyone knows that the vacuum of a tube increases with use, and that this, up to a certain point, can be obviated by the well-known expedient of heating the tube with a spirit lamp, and gauging the vacuum by adjusting the distance between the dischargers of the coil. Having got the tube into the condition required, arrange the dischargers so that the spark *just* passes through the tube in preference to the spark gap. As the vacuum increases, and the discharge again chooses the air path, it is a sign for renewed application of the heat. It will not, however, be always found that the best photographic results correspond with the best fluorescent results. The former will be attained by "a slow, long spark at the interrupter, or with a mercury interrupter, which would cause an intolerable flicker on the screen. Hence follows the necessity for screen work of a large coil and current, since the energy required cannot be secured by slowing and 'filling' the spark."† A distinction must be drawn between the *quantity* of X rays and their *penetrative power*. That is to say X rays may differ considerably in character, and it is of consequence to study the conditions upon which these differences depend.

Prof. S. P. Thompson finds that during steady exhaustion of a tube the following points are noticeable:—(1) With a low vacuum and resistance small, "so that sparks of two or three millimètres would scarcely pass between the dischargers in preference to the tube," slight phosphorescences show on the tube, but no fluorescence on the screen. (2) As exhaustion proceeds "there is an almost sudden increase in resistance, the discharger spark rising to several centimètres in length, and at the same moment strong fluorescence appears on the screen." The whole tube, both before and behind the anode, fluoresces, except in a line in the plane of the anode. These rays do not show nearly so much difference between the bones and flesh of the hand as at the next stage. (3) With yet further exhaustion the discharger spark lengthens, the part of the bulb in front of the anode is more brightly lit, while that behind is less so, till the tube behind is nearly dark and the screen does not fluoresce at all to the rays from the back of the anode. The difference of transparency between the bones and the flesh (of the hand) is now most marked, and for work in this range such is the best condition of the tube. (4) Carrying the vacuum still further, and necessarily pushing up the current to overcome the resistance the rays penetrate both flesh and bone till there seems (in a hand) little difference of shadow between them.

Mr. Campbell Swinton has studied the conditions upon which the successful working of the tube depends, and his conclusions are as follows:—

"1. The penetrative value is higher for a high vacuum than for a low vacuum.

"2. It is higher when the electrical power applied is great than when it is small.

"3. It is higher when the resistance of the tube is great than when this resistance is reduced by magnetic means.

"4. It is higher when the distance between the cathode and anti-cathode is small than when the distance is great.*

"5. It is higher when the cathode itself is small than when it is large.

"6. It is higher when, as a consequence of one or more of the above, the potential difference between the cathode and the anode portion of the tube, and consequently the electrical excitation of the cathode, is great than when it is small.

"On the assumption that the cathode rays consist of negatively charged molecules that are repelled from the similarly electrified cathode with an initial velocity that depends upon the degree of electrical excitation of the cathode, the above conditions are those that would conduce

* Recent meeting of Glasgow Philosophical Society.

† "The Induction Coil in Practical Work." By Lewis Wright. (Macmillan.)

* So far as the present writer is aware, the R. of the tube is higher when the shifting cathode is at the greatest distance from the anode; but *vice versâ* with a shifting anode—i.e., the nearer the anode the higher the R. This seems to be connected with the different conditions of shifting in a bulb and shifting in a tube (?).

to a high average velocity of the molecules at the moment at which they strike upon the anti-cathode, and at the same time to a high average difference of potential between the travelling molecules and the anti-cathode at the moment of impact."

Besides warming the tube there are several other means of bringing down its vacuum. One expedient is to send a much smaller current through the tube the reverse way.

Mr. Crookes' method is to heat a small subsidiary potash bulb. An auxiliary tube containing a carbon filament with two terminals—in other words a small incandescent lamp—has been used by Prof. Morton. On passing a separate current through the filament a certain amount of occluded gas is given off. In a German tube known as the "Penetrator," in which the anti-cathode is slightly concave instead of flat, and the anode a ring of aluminium very much nearer the cathode and much further from the radiator, there is a separate chamber containing a small piece of palladium; by warming this the vacuum can be lowered.* It may be that the vacuum of the tube is too low for the work it has to do. In the absence of an adjustable cathode the vacuum must be raised by sending repeated discharges through it for a long time; in fact, by making a new tube into an old one.

Only second in importance to the vacuum tube is the contact breaker of the coil. None of the interrupters at present in use are quite satisfactory. This point will form the subject of a paper in the next number of "The Archives."

The services of radiography in surgery and medicine are fully recognized and full of promise. Even in pathology, anatomy, and physiology it has been turned to account, and it is quite possible that it may eventually prove a helpful addition to therapeutics. It now also bids fair to prove useful in other "arts and crafts." It has been used, or its use suggested, in distinguishing real gems from artificial ones; to discover the fraudulent introduction of mineral substances into textile fabrics to increase their weight; to discover the contents of packages in the parcel post; to recognize explosives and contraband in baggage; to age and oxidize alcohol; to test insulation in the construction of cables; to ascertain cohesion in welding.

The greatest, if not the most useful of its achievements up to the present time, is probably the radiograph of the entire skeleton at one exposure, which appears in the present number.

Reviewing its services to surgery, it has localized the exact position of a bullet in the brain (Lennander,* Eulenberg,† Benedikt‡) and of a needle in the tonsil,§ rendering their extraction comparatively easy. It has followed up a Murphy's button after operation.‖ The expedient of making the patient swallow nitrate of bismuth cream has disclosed the existence of a fusiform dilatation in the œsophagus.¶ Vesical calculi have been clearly shown and measured. Such a case appears as an illustration in the present number of this journal. A hairpin in the bladder, which had been diagnosed by other means, has been clearly shown.** Mr. Henry Morris†† finds that "owing to the position of the kidneys close to the vertebral column, the depth of the cavity, the thickness of overlying tissue," it has so far proved impracticable to obtain a radiograph of renal calculi; but in this connection it may be pointed out that Dr. J. Macintyre‡‡ had already shown "an obliquely placed elongated deposit, evidently of a calculous nature," in the position of the kidney, and had expressed an opinion to the surgeon that there would not probably be found a well-formed stone. The operation was successfully performed, and at the deepest part of an old cicatrix, resulting from a previous operation for renal calculus, an ill-defined calculous mass was found, and removed with a spoon. In experiments on the dead body, the relative permeability of calculi is shown by the pale shadow of the urates, the darker shadow of the oxalates, and the comparatively clear image of the crystalline phosphates contrasted with the dark shadow of the amphorous ones.§§ Lime salts are more opaque than those calculi composed entirely of uric acid and urates.‖‖ Biliary calculi, being comparatively transparent (they have half the shadow-casting power of vesical calculi ¶¶), have hitherto eluded radiographic observation.

It is in the province of bone surgery and in the detection of foreign bodies that the new diagnosis has hitherto done its most useful work. It has made clear dislocation and fracture, both recent and old; it has thrown light upon

* "The Induction Coil in Practical Work." By Lewis Wright, pp. 135-139. The present writer believes that Palladium was first used for this purpose by an English maker, Mr. Fram.

* Kümell Ger. Surg. Soc., April, 1897.
† "Deut. Med. Woch.," August 17th, 1896.
‡ Benedikt, "Wiener Med. Presse," June 27th, 1897.
§ Kümell Ger. Surg. Soc., April, 1897.
‖ *Ibid.* ¶ *Ibid.*
** Seiffart, "Centralblt. für Gynak," No. 1, 1897.
†† "Lancet," November 14th, 1896.
‡‡ "Lancet," July 11th, 1896. §§ Frisch.
‖‖ Morris, "Lancet," November 14th, 1896.
¶¶ Morris, "Lancet," November 14th, 1896.

congenital dislocations of the hip* in doubtful cases, distinguishing it from coxa vara. Not only useful in diagnosis, it has by observations taken through the fixing apparatus kept the surgeon informed of the progress of the case, and apprised him of anything untoward in the position of the parts. M. Kummell has been able to show that, notwithstanding the characteristic "snap" which is supposed to accompany the slipping of the part into its place, reduction had in certain cases not been effected. His radiographic studies enable him to distinguish three kinds of luxation.† (1) When the cotyloid cavity is absent; (2) when it is very little developed; (3) when it is sufficient to receive the head of the femur.

The same author has detected tubercular deposit in the cervical vertebræ, and his diagnosis has led to a successful operation. He considers that in inflammatory lesions of the bones, osteomyelitus, tubercle, syphilis, a vast field lies open to radiography.‡ M. Hoffa§ points out the usefulness of this method of diagnosis in scoliosis, especially in the way of ascertaining the deviation of the bodies of the vertebræ relatively to that (always less marked) of the spinal apophyses, and thus to gauge the effects of treatment. He has seen in congenital dislocations reduced by manipulation alone, the head of the femur slip out of the cotyloid cavity in a direction forwards and upwards, and this some months after reduction.

Its uses in osteoplastic surgery are shown in two cases detailed by Ollier,‖ in which the shape and dimensions of newly formed bone following the free removal of necrosed tibia very clearly appears. A third case shows the process of development of new bone following transplantation of periosteal and osseous grafts.

Oberst¶ is convinced from radiographic examination of bones on every aspect that in a great number of fractures it is impossible to secure "an ideal coaptation"—that is to say, an absolutely correct position of the limb after cure of the fracture. At the same time M. Braun** pointed out that a great many fractures recover with a more or less pronounced bony deformity, but without any impairment of motor power.

It must be admitted that, useful as the new diagnosis has proved in revealing the presence of foreign bodies, it often fails to disclose their exact position, and operative failure is not uncommonly the consequence.

* Noble-Smith, "Brit. Med. Journ.," December 12th, 1896.
† German Surg. Soc., 1897. ‡ German Surg. Soc., April, 1897.
§ *Ibid.* ‖ "Bull. de l'Acad. de Med.," No. 20, 1897.
¶ German Surg. Soc., 1897. ** *Ibid.*

A series of papers on the important subject of localization will therefore appear in this journal.

Medicine has profited less extensively than surgery, but with improvements in apparatus there is some evidence that its turn is coming. The fluorescent screen clearly shows the skeleton of the thorax, and the light spaces occupied by the lungs contrast with the darker areas of heart and vessels, and the still deeper lines of the ribs that arch across. An aneurysm of the thoracic aorta at its union with the arch has been shown, which other means of diagnosis had failed to detect.* Its exact seat, form, and dimensions were clearly made out, and the sudden death of the patient a few days afterwards afforded an opportunity of verifying the observations. In this case the calcareous deposits on the aortic wall showed a well-marked contrast in relative transparency with the sound parts, or such as were only atheromatous. Wasserman† and others have shown cavities in the lung, sometimes in cases where such a condition was not previously suspected.

In the radiograph the cavity showed as a clear spot on a darker ground. Some time afterwards the stethoscopic signs confirmed what the radiograph had shown. An illustration which appears in the present number of this journal may also be referred to. Bouchard‡ and others have shown the existence of pleuritic effusions as well as morbid conditions of the lungs, heart, and pericardium. A case is recorded by Béclère§ of empyema in a child five years old where the condition had for some months been regarded as tubercular, and operative measures subsequently confirmed the radiographic diagnosis. The radioscope has also afforded an opportunity of studying the movements of the diaphragm in health and in disease. In certain cases of asthma it has been shown that one-half of the diaphragm remained absolutely immovable in the position of maximum inspiration, and only began to move again after the coughing fit, which, terminating by the characteristic pellets, marked the end of the paroxysm.

Also by means of the fluorescent screen Benedikt, of Vienna, has recently made interesting researches on the position and action of the heart and its relation to the diaphragm.‖

It has been shown by Reny and Contramoulins¶ that this method of investigation may be applied to the study

* MM. Béclère, Oudin, and Barthélémy, "Soc. Med. des Hôpit."
† Med. Club of Vienna, 1897.
‡ "Sem. Méd.," December 9th and 23rd, 1897.
§ "Com. Soc. Méd. des Hôp."
‖ "Rev. d'Electrother.," March, 1897.
¶ Soc. de Biolog., 23rd January, 1897.

of muscles, tendons, and ligaments. Dutto radiographed the arteries of the hand, after injecting solution of calcium sulphate.

It is certain that the Roentgen ray, or some part of the process connected with its production, is capable of producing an effect (so far as is yet known, usually an injurious one) on the living organism.* The question has been asked, Is there such a thing as X ray dermatitis? This has been answered in the negative by Mr. Lynn Thomas,† and affirmatively by Prof. Elihu Thompson.‡ The point cannot be considered quite definitely settled, but the case against the X ray is undoubtedly a strong one. These traumatic effects have been attributed to ozone, to particles of platinum, and by one gentleman even to *heat*. The latter theory will not commend itself to those who are daily in the habit of working on the human body with temperatures of 250° to 300° Fahr. without injurious effects.

The therapeutics of the Roentgen ray show a slowly growing literature. M. Sormani§ has established the fact that in cultures submitted to the action of "the ray" the pathogenic organisms do not undergo attenuation. But Fiorentini and Luraschi‖ have experimented on guinea-pigs with intraperitoneal injections of cultures of human tubercle, and repeated experiment leads them to the conclusion that the process of exposure to Roentgen rays retards in a remarkable way the development of tuberculous infection in animals, *i.e.*, the tissues acquire a greater resistance to the infection. M. Rendu¶ reports the case of a patient suffering from hectic, with congestion, inflammation, and suppuration of the lungs or pleura of uncertain origin, which was daily submitted for fifty minutes to the action of the rays. After the fourth séance the pyrexia ceased with a crisis of diuresis and sweating. Convalescence set in and ended in complete recovery.

In a case of cancer, "a small epithelial cancroid ulcer of the mouth," pain is reported to have been diminished and narcotics rendered unnecessary by prolonged and frequent exposure to the rays, the number of the exposures having reached two hundred, when the patient died of pneumonia.* A case of cancer of the stomach is also related which was treated in this way, and it is considered that the treatment produced a general amelioration in the condition of the patient—an absolute disappearance of the pain and a diminution in the size of the stomach.†

Freund‡ reports a case of hairy pigmented nævus covering the neck, back, and upper part of arm. Daily exposures to the rays of two hours' duration. After the eleventh séance the hair began to fall out, and resulted in complete clearance of occiput, neck, and back. Eight days after the hair commenced to fall a dermatitis appeared, which comparative experiments have shown to be due to the rays and not to calorific action or electrical discharge from the focus tube. The hairs of the head fell off more easily than those of the nævus. He considered the Roentgen effects cumulative, and due to chemical and nutritive changes in the tissue. M. Zemann§ examined the hairs microscopically and found their roots atrophied and swollen. The atrophic changes predominated.

M. Kaposi ‖ considered that the falling out of the hairs in the nævi was scarcely analogous to what occurs in baldness. It is probable that the Roentgen ray produces first a dilation, then a paralysis of the vessels. It may be expected, therefore, that when the papillary vessels have recovered their tone the hair will begin to grow again.

Prof. Daniel,¶ of Vanderbilt University, is stated to have secured a simple depilatory action without inflammatory or other visible lesions or secondary symptoms preceding the falling out of the hair. So far as the present writer is aware, there has not been any further report in either of the latter cases as to how far the depilatory effect has proved permanent.

From the foregoing it is apparent that Roentgen ray therapeutics rest as yet on the slenderest possible foundation; and it is, moreover, a significant fact that, notwithstanding the widespread knowledge of the technical procedure and the interesting nature of the subject, affirmative evidence does not more quickly accumulate.

* Crocker: "Brit. Med. Journ.," January 2nd, 1897.
Marceuse: "Deutsche Med. Woch.," July 23rd, 1896.
Drury: "Brit. Med. Journ.," November 7th, 1896.
King: "Canad. Pract.," November, 1896.
"Nature," October 29th, 1896.
"Lancet," June 26th, 1897.

† "Brit. Med. Journ.," March 27th, 1897.

‡ "Electrical Review."

§ Atti del Istituto Lombardo di Scienze e Lettre, 4 Guglio, 1896.

‖ "Rev. d'Electrother.," March, 1897.

¶ Soc. Med. des Hop., "Rev. d'electrother.," March, 1897.

* "Lyon Méd.," July 16th, August 9th, and December 28th, 1896.

† *Ibid.*

‡ Méd. Soc. of Vienna. "Revue d'Electrother.," March, 1897.

§ *Ibid.* ‖ *Ibid.*

¶ "New York Med. Record," April 25th, 1896.

Description of Plates.

PLATE XXV.

A CASE OF FRACTURED OLECRANON.

By THOMAS MOORE, F.R.C.S., Surgeon to the Miller Hospital.

The discovery of Roentgen will, I believe, find its most useful application in the treatment of fractures and dislocations. It not only does away with many of the painful manipulations of diagnosis, but is useful in ascertaining how far reduction and fixation have been satisfactorily performed. A radiograph may be taken through the splints and bandages if the former are of wood or aluminium, and the latter are not soaked with lead lotion or dusted with iodoform, both of which are impervious to the rays. Ordinary adhesive plaster also spoils the picture, if much be used, for nearly all plasters of the pharmacopœia contain lead. Rubber plaster is better. Often a fractured bone is so splintered, or the ends are drawn over one another so much by muscular action, that it is impossible to get a good result by the ordinary method of extension and the application of splints and bandages. In such a case a Roentgen photograph will be a certain guide as to the extent of the mischief, and the fractured bone may be wired or screwed together if it seems necessary. This will be, in the not distant future, I believe, the routine practice in all fractures except the very simplest.

The accompanying radiographs of a fractured olecranon before and after treatment, well exemplify the use of screws. The patient, a woman, aged sixty-one, was admitted into the hospital about eight months ago. She had fallen down several stairs upon her elbows. The joint was movable but flexed, and so much swollen (as is apparent in Radiograph No. 1) that an accurate diagnosis by manipulation was impossible. It is evident that there was simply a fracture of the olecranon, with an inch separation of the fragments.

Ten days after the accident I cut down on the fractured ends and brought them together with a well-boiled steel screw, coated with silver. The shaft of the ulna was very soft, and it was necessary to take the screw uncomfortably near to the joint to obtain a good hold. Another time I intend to use a longer screw and drive it down the shaft of the bone, as recommended by Mr. Arbuthnot Lane.

The patient left the hospital in eight weeks, and next day, in spite of advice, worked at the wash-tub, and does so still, I believe, with the screw *in situ*.

No. 2 was taken on an Eastman's X ray paper; No. 1 on an ordinary plate, before the X ray paper came out. A transparency was afterwards made and a print taken from that on Eastman's paper, to make it match its fellow.

The screw is superior to a wire, I believe, in such cases, as the broken ends of the bone

can be kept closer together by the former. In Vol. I., No. 3, Plate XIII. of this publication is a very good skiagram by Dr. Morrison, of Hartlepool, of a similar case which had been wired. That shows an excellent result, but if it is compared with mine it will be apparent that the screws bring the fractured ends closer together than the wire does.

PLATE XXVI.

J. F., aged sixty-eight, presented himself as an out-patient at the Sussex County Hospital on September 25th, 1896, with evident symptoms of obstruction of the œsophagus. There were no physical signs in the chest; very little pain except a "boring" one from time to time in the back between the shoulders. There was slight evidence of atheroma of the arteries. The patient remained in much the same condition under treatment until June, 1897, when the obstruction became more complete. He refused to enter the hospital, and died practically of starvation and exhaustion early in July. No autopsy. The diagnosis lay between carcinoma and aneurysm.

PLATE XXVII.

PHTHISIS.

By C. W. CHAFFEY, M.D., Brighton.

N. C., aged five years, was admitted to the Children's Hospital, Brighton, early last year for phthisis of several months' duration. The child was much wasted, and presented signs of excavation at left apex with those of fibroid infiltration affecting chiefly the right upper lobe, and general bronchitis. The radiograph, by Mr. Ernest Payne, is typical of what has been found in similar cases that he has taken, viz., light area on darker ground giving a fenestrated appearance. The child improved for a time under treatment, but eventually died with profuse hæmoptysis.

PLATE XXVIII. (*a*).

VESICAL CALCULUS.

By MACKENZIE DAVIDSON, Esq., London.

Prof. Ogston, of Aberdeen, having diagnosed the presence of a calculus in the bladder, sent the patient to me, so that I might have the opportunity of taking a radiograph of his pelvis, and, if possible, show the presence of the calculus. The method I adopted was to make the

patient lie face downwards upon a rapid photographic film, which was wrapped in two folds of black sateen cloth placed under the pelvis. The Crookes' tube (made by Greiner and Freiderichs, Stützerbach) was so placed that the Roentgen rays should pass obliquely through his pelvis, thus preventing as far as possible the bones intercepting the rays on their passage through the bladder and other soft parts. The patient's position ensured the calculus falling forward on the front wall of the bladder, and thus coming close to the photographic film.

The radiograph shows the shadow of the stone, which I estimated to be about 3·4 centimètres in diameter. (The actual lithotrite measurement makes it 3·1 centimètres.) The records of the exact distance of the tube and the exposure given unfortunately have been mislaid. I think it was about ten minutes' exposure. An Apps' ten-inch spark coil was used. Of course the practical importance of revealing a stone in the bladder by means of the Roentgen rays is not very great, as there are other and readier means of doing so. But it is not without interest, especially as what we do really want is to be able to diagnose with certainty a calculus in the kidney.

PLATE XXVIII. (*b*)

A CASE OF FALSE JOINT AND DEFORMITY OF LEG.

By NOBLE SMITH.

Surgeon to the City Orthopædic Hospital, and Surgeon to All Saints' Children's Hospital.

Miss R., aged twenty-two. It was said that at the age of three she ran about quite well, but soon after that the left leg began to give way, and she ceased to be able to walk. There was no pain. At the age of sixteen she was getting about on crutches, the leg being quite useless to her from its deformity, its weakness, and from being two and a quarter inches shorter than the other. I devised a boot with an iron support, which enabled her to walk about comfortably without crutches.

In January, 1897, she consulted me regarding a new support, as the other was wearing out. I then advised operation, and had a skiagram taken to show the position of the bones. This demonstrated what seemed to be a false joint, or at least incomplete osseous union.

On January 29th, 1897, I divided the tibia and fibula from behind forwards, but did not quite penetrate to their anterior surfaces, fracturing the last portion with the view of insuring the retention of the bones in a straight line.

In straightening the parts a gap was thus produced, and I adopted this plan (instead of cutting out a wedge) with the object of increasing the length of the limb as much as possible. A skiagram taken after the patient began to get about again did not show the parts very well, but I hope to obtain another at some future time. The casts taken before and after operation show the satisfactory result obtained by the treatment.

With regard to the nature of the case, it seems most likely that the patient had a fall when

a child and sustained a green-stick fracture. The deformity increased gradually as long as the patient walked about, and even at the later period, with the help of the special boot and support, it seemed to get worse.

PLATE XXIX. (*a*) AND (*b*).

A METHOD OF LOCALIZING A BULLET.

By THOMAS MOORE, F.R.C.S., Surgeon to the Miller Hospital.

The patient, a healthy young man, aged twenty-one, came to the hospital three months ago with a small conical pistol bullet in his hand, which was much swollen and very painful. Photograph A was taken on an Eastman's X ray paper and plainly shows the bullet in the palm, apparently resting on the bones of the carpus.

With the picture before me I cut down into the palm but failed to find the bullet after a prolonged search, although I laid bare the bone. I tried several experiments in localization by making lines with various paints of lead, mercury, and bismuth on the hand. All of these were photographed on a plate, more or less plainly, but did not seem to show lines definite enough for the purpose. It then occurred to me to have a "grid" made of iron wire, as shown in Photograph B. This was painted on one side with an aniline dye and fixed to the palm. The palm, with the grid *in situ*, was then placed on a sensitive plate, a layer of celluloid being interposed to prevent the dye from getting on the plate. The result was that the hand and the photograph were each marked by the grid. I then cut down a second time into the palm, with the assistance of Mr. Chevalier, House Surgeon, and, feeling quite sure that the bullet must be under the knife, went on further than before, and found it wedged in firmly between the os magnum and trapezoid bones, and nearer to the back than to the palm of the hand. Since then I have had a finer "grid" made by a stencil-plate maker, which is more flexible and adapts itself to the part to be photographed.

PLATE XXX. (*a*).

A CASE OF CONGENITAL DISLOCATION OF THE HIP.

By R. NORRIS WOLFENDEN, B.A., M.D. Cantab.

This is a radiograph of the right hip joint of a boy aged seven and a half, exhibiting a congenital dislocation. The boy has been under observation since birth. The shortening of the limb is about one and a quarter inches, but the boy runs and jumps as well as any boy of his age, and enjoys perfect health. The dwarfing of the pelvis, previously unsuspected,

is clearly shown in the photograph. The photograph was taken by me in February, 1897, with a ten-inch spark coil, giving an exposure of about half an hour, with occasional rests, and using the mercury interrupter in place of the ordinary hammer. A Watson penetrator tube was employed, and placed about two feet two inches above the patient, in order to avoid unpleasant effects upon the skin, the limb being covered with flannel clothing.

PLATE XXX. (*b*).

ENTIRE ADULT BODY AT ONE EXPOSURE.

By WILLIAM J. MORTON, M.D., New York.

As is well known, X ray pictures of the various portions of the skeleton have been taken at successive exposures and patched together, but, so far as the writer knows, this is the first X ray picture at one exposure of an adult skeleton. The apparatus employed was a twelve-inch induction coil, whose primary was supplied from the 117 volt Edison current of the street mains, and made and broken by means of a break wheel, causing about 5000 breaks a minute. Both condenser and blower were employed to keep down the spark on the break wheel. At a revolution of the break wheel of 5000 per minute, the coil affording a free discharge of sparks across a five-inch air gap; current through the primary of the coil, 3 6—10; voltage at the terminals of the primary, 75; an ordinary Crookes' tube with a commencing vacuum corresponding to a spark of two inches, which gradually rose to eight inches. Platinum anode was run at continuous red heat. Distance of tube from plate, four feet six inches. Time, including stoppages, thirty minutes. The woman was fully clothed, excepting as to corsets. (This Radiograph, with descriptive details, has also appeared in the "Electrical Engineer," New York.—ED.).

Notes.

A State Laboratory for Roentgen Ray Work.

"The first State Institute for investigations with Roentgen rays has been fitted up in Berlin, and Prof. Grunmach has been appointed to direct it. The new Institute is in close proximity to the Charité and other clinical establishments, at 18, Louisenstrasse. Patients are seen between eleven and one on week-days, and every facility which the latest triumphs of invention have provided are afforded there for the processes of inspection, actinography, and so forth. The Investigation Room opens into the Laboratory, in one corner of which is a photographic dark-room, and a glass enclosure for the development of the negatives. Before and after the hours reserved for the treatment of patients the rooms are used for experiments, lectures, and demonstrations, attended by students and physicians."—*Morning Post*, July 12th, 1897.

Dr. Russell's Experiments.

The following "science note" appears in the *Pall Mall Gazette*, July 5th :—

"One of the most remarkable papers ever read before the Royal Society was that by Dr. Russell, on the power possessed by quite a number of familiar substances of emitting rays which will affect a photographic plate in the dark. Dr. Russell's experiments are an outcome of the interest in invisible rays following Prof. Roentgen's discovery, and seem to confirm the statements made by numbers of observers at the time that Roentgen effects could be got in different ways, and with various kinds of apparatus. These statements were not received with very much faith, so that one of our poets has said, after Kipling :—

"'There are nine-and-sixty ways of producing Roentgen rays,
And every single one of them is *wrong*.'

Dr. Russell's experiments throw a new light, however, on the matter. The metals, mercury, zinc, cadmium, aluminium, magnesium, tin, antimony, and cobalt, with one or two others, are all, according to him, able to impress an image on a sensitive plate if they are locked up near it for a week or so in the dark. Other metals were without this effect, which, however, is so clear in some instances that a design cut on a plate of the metal will make itself seen in the photograph.

"Nor are metals the only substances capable of exerting this effect. Young larch and fir wood cut into sections will give an image in which the ring structure and bark are visible. Certain kinds of strawboard, copal varnish, and some printers' inks seem to have the property of emitting these mysterious radiations. Dr. Russell even specifies some of the inks which yielded good or bad results. The *Westminster Gazette* and the *Standard* are printed with sensitive inks. The *Morning Post* and *Echo* are not. The *Times* comes between them. What this power is that has suddenly been brought to light in so many objects round us, and how wide is its action, no one can say. We are still at the surface of the problem. Becquerel showed some time ago that one class of substances, the compounds of uranium, possessed it in a marked degree. Dr. Russell has shown that it is by no means confined to uranium compounds, but occurs to a greater or less extent in many of the most unlikely substances."

Influence of Roentgen Rays on Plants.

"The new number of the Royal Microscopical Society's *Journal* gives a brief account of some experiments on plants with Roentgen rays conducted by Herr Istvanffy. Crookes' vacuum tubes were used. It was found that the X rays penetrate only the woody tissue. The veins of a camellia leaf under treatment appeared white in the image. All the other tissues, whether containing chlorophyll or not, were proof against the rays. It is of great importance that we should ascertain exactly what is the influence of these rays on living things, both plant and animal, for no doubt grave considerations of health are involved."—*Methodist Times*, July 8th.

M. Tesla and Roentgen Rays.

In a contribution to the *American Electrical Review* M. Tesla writes :—

"Commonly my bulbs were capable of showing the shadow of a hand on a phosphorescent screen at distances of 40 or 50 feet, or even more ; and to the action of these bulbs myself and several of my assistants were exposed for hours at a time, and although the exposures took place every day not the faintest hurtful action was noted—as long as certain precautions were taken. On the contrary, be it a coincidence or an effect of the rays, or the operation of some secondary cause present in the operation of the bulbs—as, for example, the generation of ozone—my own health and that of the two persons who were daily under the influence of the rays, more or less, has materially improved, and, whatever be the reason, it is a fact that a troublesome cough with which I was constantly afflicted has entirely disappeared ; a similar improvement being observed in another person."

Commenting on this article, the *Birmingham Post* has the following :—

"Mr. Tesla found it necessary when studying the action of the rays to employ a thin aluminium sheet, or gauze of aluminium wires connected with the ground directly, or through a condenser, as a screen between the bulb and the person. This precaution he found necessary because a certain irritation of the skin was otherwise experienced. . . . . The theory that the hurtful influences were in a large measure

dependent on either an electrostatic action or electrification also explained why burns were produced in some instances on the opposite side of the body adjacent to the photographic plate, whereas portions on the directly exposed parts of the body, which were much nearer to the bulb, and consequently were subjected to by far stronger rays, remained unaffected. It also made it easy to understand why the patient experienced a prickling sensation on the exposed parts of the body whenever injurious action took place. Finally, this view agreed with the numerous observations that the hurtful actions occurred when air was present, clothing, however thick, affording no protection, while they practically ceased when a layer of fluid, quite easily penetrated by the rays, but excluding all contact of the air with the skin, was used as a preventive."

Coal Analysis by Roentgen Rays.

"We are daily discovering new uses for the X rays. We are indebted for our latest information to Mr. Caryl Haskins. The density of the shadow of a coal sample viewed through a fluoroscope is dependent upon the percentage of ash, and by matching the shadow of the sample under investigation with that of a sample of coal of similar size and thickness, and with a known percentage of ash, speedy and probably quite accurate results may be obtained."—*Science Siftings*, July, 1897.

Cathode Rays and Roentgen Rays.

The following extract is from the *Electrician*, July 9th.

"*A propos* of Thompson's experiment (see the *Electrician*, January 8th) purporting to prove the existence of a third kind of rays which produce fluorescence, but are not deflected by a magnet, A. Batelli endeavours to show that there is no fundamental property possessed by Roentgen rays which is not also possessed by cathode rays. They both possess photographic action, as proved by Batelli's previous experiments. The distinguishing property of Roentgen rays which remains open to discussion is the absence of regular reflection. Batelli makes a series of crucial experiments which go to show that in no case are cathode rays regularly reflected. In one experiment a platinum mirror was mounted in the path of the rays proceeding from a concave cathode. Small metallic cylinders bearing sensitive films, covered with opaque paper, were mounted in various azimuths in front and behind the mirror. Those in front were all impressed with a gradation corresponding to diffused reflection. Those behind were impressed when the platinum foil was thin enough or when it was replaced by aluminium. Other experiments show that after a second reflection the rays have the same properties as before. But the most important result is that the action of the reflecting surface upon the cathode rays is the feebler the thinner the surface. This fact can hardly be reconciled with the assumption that Roentgen rays are due to the impact of cathode rays. Thin surfaces seem to act as filters, transmitting some of the rays and diffusing the rest. Batelli also confirms the result that the transparency of bodies for cathode rays is the same as their transparency for Roentgen rays."

The Energy Conditions necessary to produce the Roentgen Rays.

Under the above heading Prof. John Trowbridge has contributed a paper which appears in the *Proceedings of the American Academy of Arts and Sciences*, Vol. XXXII., No. 14, April, 1897. *A propos* of this paper the following appears in the *Engineer*, 2nd July :—

"It appears from the experiments that the discharge in a Crookes' tube, when on the point of emitting the Roentgen rays most intensely, is an oscillatory one, and that each discharge encounters a resistance less than five ohms. An estimate of the great amount of energy thus developed in an exceedingly small interval of time can be obtained if we suppose that Ohm's law holds for individual oscillations. This reservation is an important one, for the investigations described in this paper show that a discharge of 6in. in length encounters no more resistance during its oscillations than one of 2in. in length. In popular language, it can be maintained that a discharge of lightning a mile long encounters no more resistance than one of a foot in length. Ohm's law does not hold good for electrical discharges in air and rarefied gases. It is well known that a voltaic arc can be started in a vacuum. The author's experiments lead him to believe that in every case the arc is started by a spark, which breaks down the medium, and the arc follows. He is also led to believe that electrical oscillations are of the nature of voltaic arcs, and that the discharges in Crookes' tubes are voltaic arcs. He is thus forced to the conclusion that under high electrical stress the ether breaks down and becomes a good conductor."

The alleged reflection of cathode and Roentgen rays has also been the subject of independent observation by M. Villard. —*Bull. Soc. Française de Physique.*

Amongst the papers read before the Academy of Sciences, Paris, on July 5th, there was one on "The Magnetic Deviation of the Cathodic and X Rays," by M. G. de Metz ; and one on "The Actino-Electric Effects of the Roentgen Rays," by M. S. Puggenheimer.

Speculating on the origin of the Roentgen rays, and not dealing with "ideas that are scientific in the ordinary sense, but the result of imagination allowed free scope," Elihu Thompson writes an article in the *Electrical World*, July 3rd, from which the following is an extract :—

"Considering these matters, it occurred to the writer that a cause for the production of Roentgen rays might be found if the elements were dissociated into simple or more primordial matter. Taking the view, which has much to support it, that in the spectrum of ordinary heat and light we find all those rates of electric oscillation which characterise vibrating molecules, or the atoms of elements composing them ; that they set up waves in the ether because the ether is essentially electromagnetic ; that the great rigidity of the ether so opposed to its apparent extreme mechanical mobility is after all only a chemical or electro-magnetic rigidity, bearing no proportion to its mechanical properties, any more than the ordinary fluidity of a

chemical compound bears to the chemical stability of the compound, we arrive at an interesting supposition respecting the Roentgen ray emanation. If the residual elementary gases are broken up into simpler and finer matter within the area of the bombarded spot, the *normal electro-magnetic rates of vibration of that finer matter should be far higher in pitch or of shorter wave lengths than in the case of the ordinary spectrum.* According to this view there would be no oscillation so slow as ordinary light originating in the finer matter dissociated from the elements at the exceedingly high temperatures represented by the colliding molecules or atoms immediately at the front of the platinum anode. All the wave lengths emitted as normal to the new forms of matter, only existent at the highest temperatures, would be of the Roentgen ray order, and a spectrum of such rays might characterise the matter present, as the ordinary spectrum does the low temperature combinations. But absence of diffraction and refraction effects thus far are formidable obstacles to such analysis of these higher pitch rays."

Roentgen Rays and French Customs.

"The Roentgen rays, which have been employed to examine the interior of bombs with success by M. Girard, are now enlisted in the service of the French customs by M. Pallain. We are afraid some of the newspapers have exaggerated the dread importance of this latest application. No doubt some contraband articles may be detected in this way, but certainly others cannot. Might not a smuggler of lace, for instance, be able to stow as much as he likes of it in his bag and without fearing detection by the rays? We hear of cigarettes being discovered by this new Ithuriel, but probably the metal box containing them was the cause of it. Cigars and cigarettes, as well as lace, are vegetable matter, more or less transparent to the rays, and one could easily select and pack them so as to escape the vigilance of the 'douanier.' Perhaps we shall presently see tobaccos and other articles offered for sale 'warranted X ray proof.' Professional smugglers may also subscribe to the Roentgen Society." —*Globe*, 16th July.

THE ARCHIVES OF THE ROENTGEN RAY will for the present be published quarterly.

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(*By THOS. MOORE, Esq., F.R.C.S.*)

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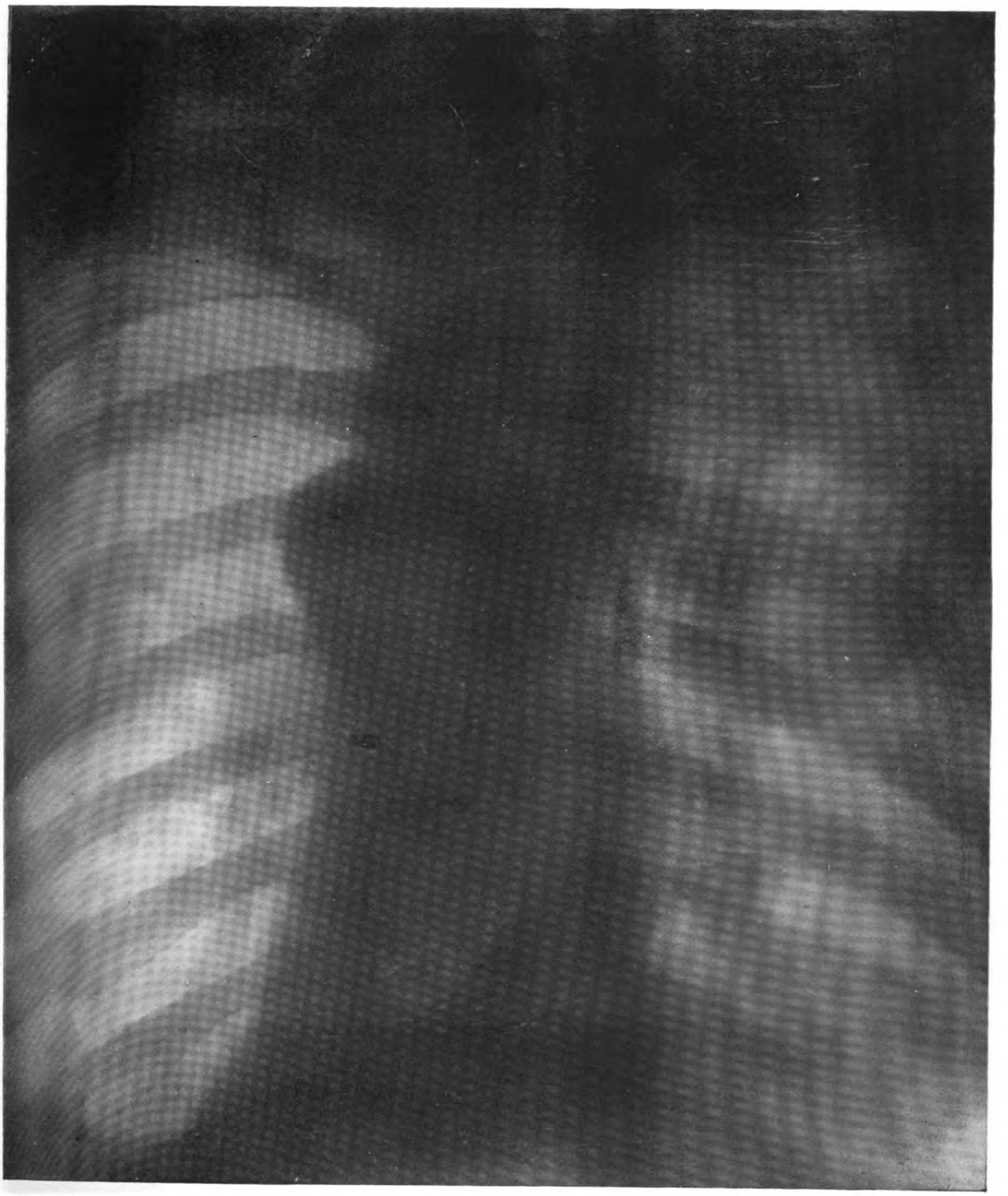

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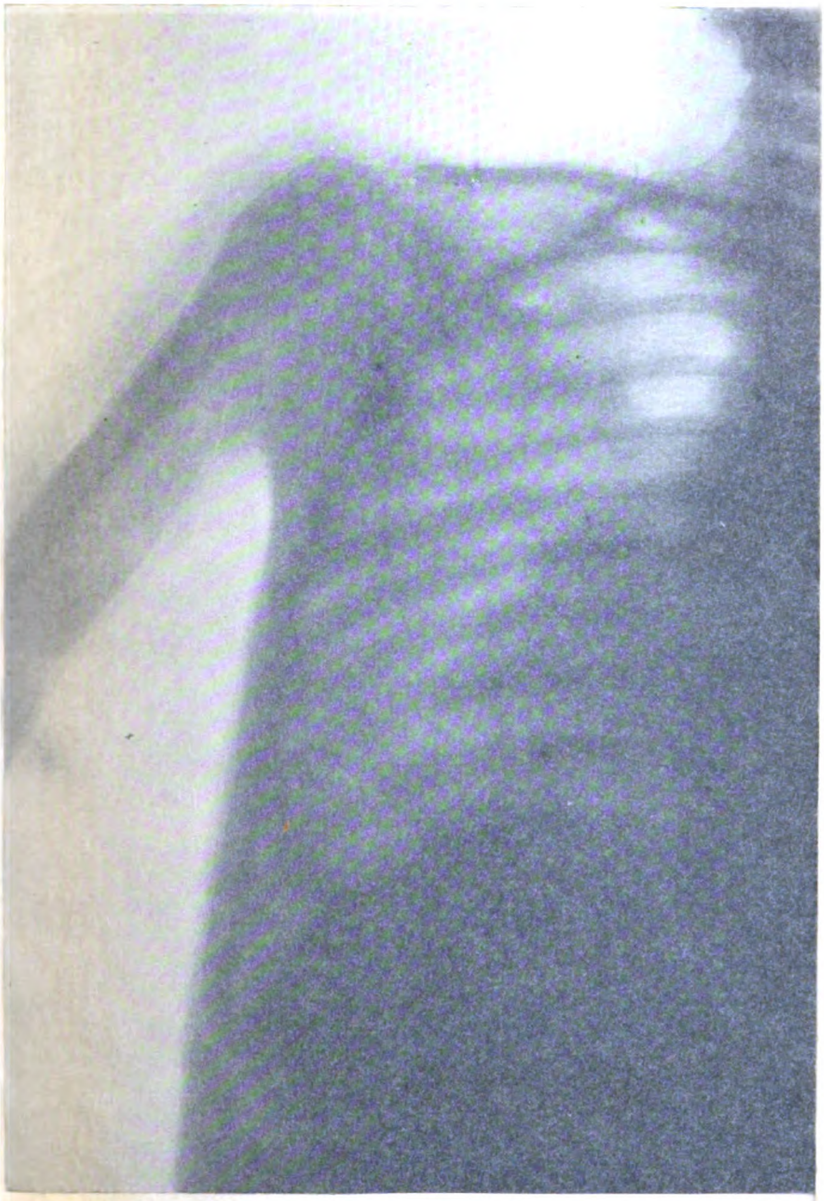

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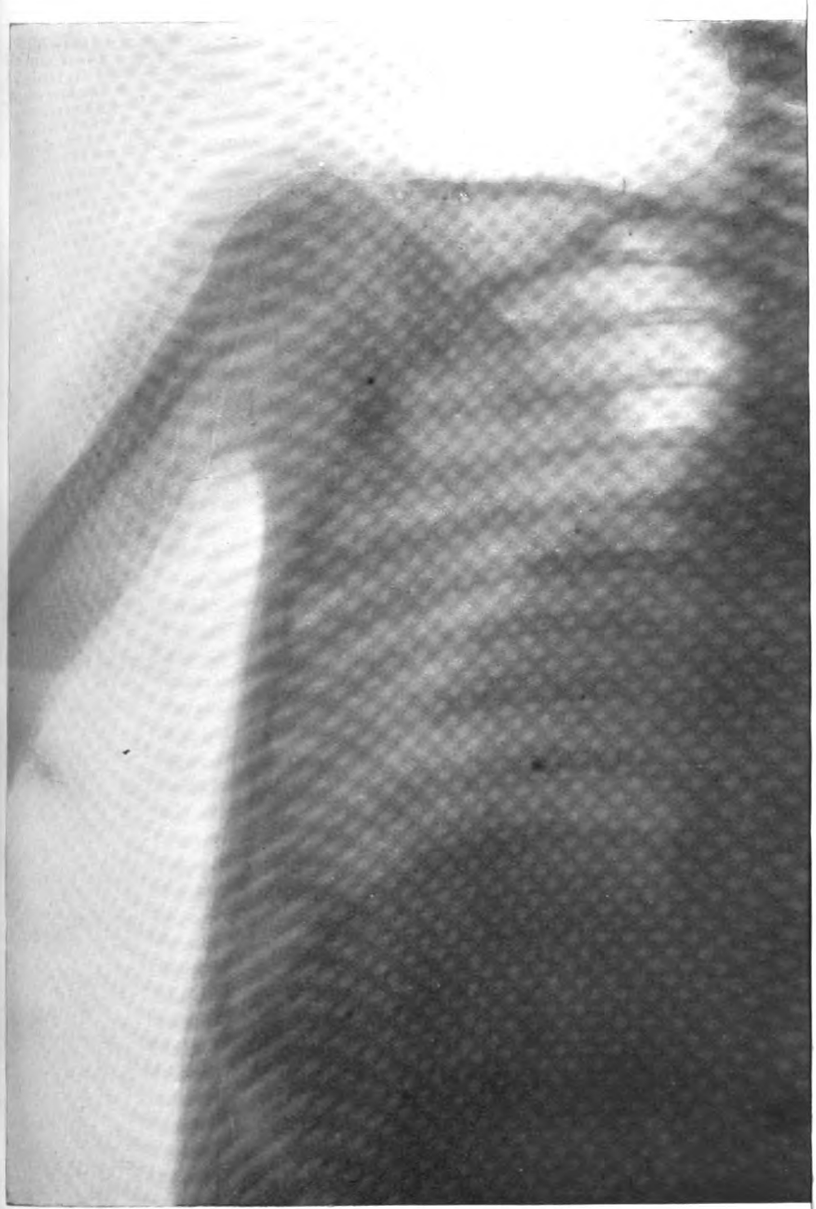

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PLATE XXVII.

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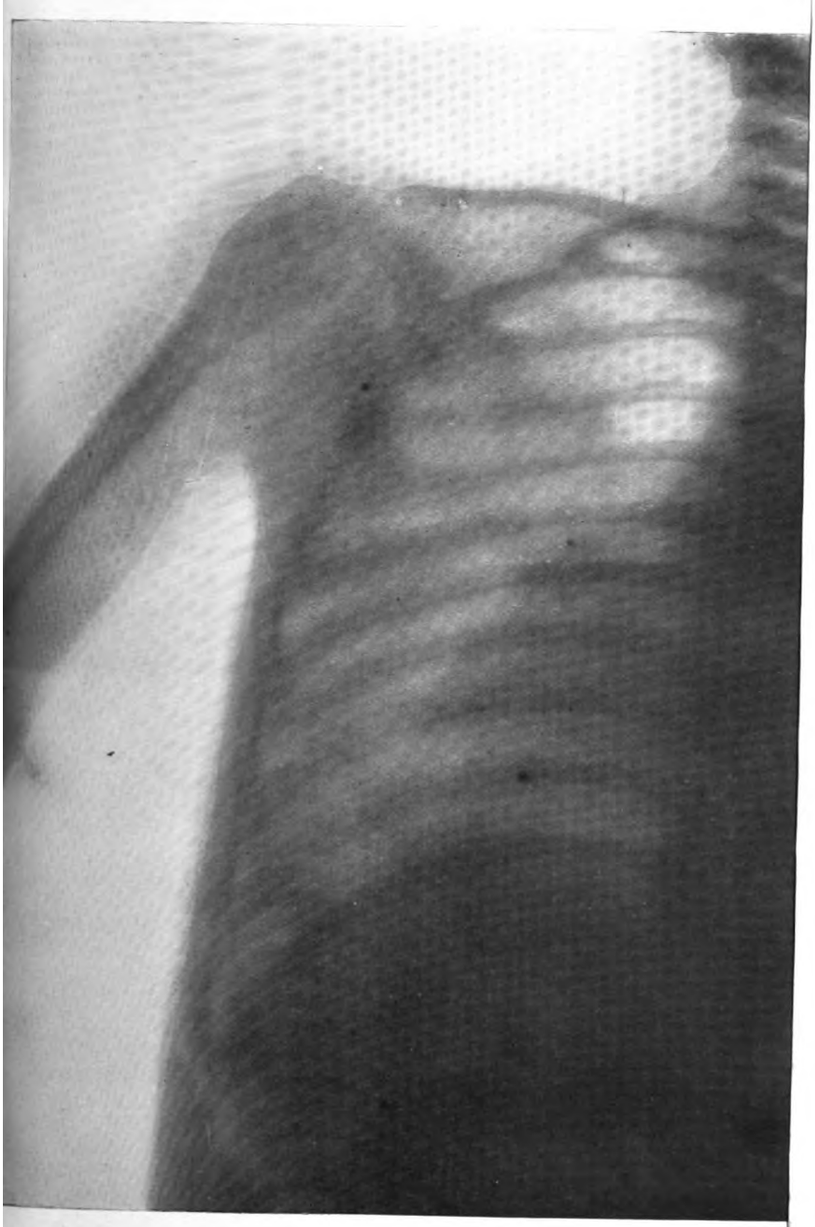

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PLATE XXVII.

...es of the Roentgen Ray.)

Vol. II.—No. 2.] NOVEMBER, 1897. [Price 4/- or $1.

ARCHIVES OF THE ROENTGEN RAY.

EDITORIAL.

The present number of "The Archives" records a very interesting and significant event. It may be remembered that at the first meeting of the Roentgen Society, held at 11, Chandos Street, on June 3rd, it was decided that at the next meeting in the autumn there should be a formal Presidential Address, and at the same time an exhibition of radiographs, apparatus, and methods. This took place at St. Martin's Town Hall on the evening of Friday, November 5th, and proved to be not only a meeting of the Society, but a "society" meeting in a sense that may have surprised some of its original promoters. The suite of rooms answered well the requirements of the occasion. In the Large Hall, at 9 p.m., the President delivered his Address. Adapting itself to the very varied elements of which the large audience was composed, it sketched the origin and ancestry of the Roentgen ray, and then dealt with improvements in apparatus, advances in results, and increasing usefulness in application; the latter no longer limited to surgery and medicine, but extending even to botany, mineralogy and metallurgy. The electrical and chemical properties of these rays were then discussed, and coming at last to their physical nature it was pointed out that now, perhaps, we are within measurable distance of being able to say "Yes" or "No" to the question whether they are of the nature of waves. If the latter, some of the laws of wave propagation ought to be applicable. Amongst these there is Kirchhoff's law, which announces the reciprocity of radiation and absorption. Now if, as appears probable, the absorptive power (opacity) of a substance be proportioned to its atomic weight, and Kirchhoff's law can be applied, it would follow that the substances of greatest atomic weight ought also to be the best emitters. As a matter of fact, this is what the speaker had proved to occur in the case of uranium—the metal of greatest atomic weight. This Address is printed *in extenso* on another page. The forty minutes that it took in delivery was none too long; and the proposer of the vote of thanks did nothing more than voice the mind of the entire assembly when he alluded to the far too little prominence that had been given in the address to the important and original researches of the President himself.

On the walls of the hall a large number of radiographs were displayed, forming probably the most advanced and representative collection that has yet been brought together. The progress that has been made in methods and apparatus could be strikingly realized by comparing the wonderful finish, definition, and detail of these pictures with the "fuzzy" specimens of early work that, less than two years ago, all the world wondered at. Nearly all the more prominent manufacturers had tables assigned to them for the display of instruments; coils, focus tubes, batteries, contact breakers, fluorescent and intensifying screens, photographic films—all appeared in endless variety, and brought under view the entire arsenal of X ray apparatus. Amongst the objects claiming special notice was one of Mr. Nikola Tesla's new electric oscillators, which had been specially sent over from New York for this occasion by Mr. Tesla. At other tables in the same hall demonstrations were given of localizing apparatus which, by means of ingenious mechanical methods, were able to disclose the exact position of opaque foreign bodies embedded in the tissues. A reflecting stereoscope was shown which exhibited X ray pictures in relief with the object of its natural size. Seen in this way, an injected brain was a very effective object, the observer being able to realize the contours of its surfaces and to look into its depths. Roentgen ray literature was represented in a recent work by the Secretary of the Society, and on a neighbouring table appeared "The Archives of the Roentgen Ray."

Through the voluntary efforts of one or two members of the Council an excellent musical programme was provided, the concert being opened by Mr. W. Webster, whose magnificent voice appeared to much advantage in "Il

Sogno," by Mercadante, with a 'cello obbligato played by Mr. Prosper Burnett. The latter afterwards charmed the audience by his sympathetic rendering of Godard's well-known "Berceuse." Miss Cordelia Grylls sang songs by Schumann and Meyer Helmund with great taste and feeling. The next item was a masterly rendering by Mr. S. Webbe of "Liebestraum" (No. 4), by Liszt. Lastly came two songs by Mr. Henry Piercy, which delighted a large number of appreciative listeners. Owing to the lateness of the hour, and much to the disappointment of the audience, it was found impossible to carry out to the end this excellent and well-arranged programme.

In the smaller hall lantern demonstrations were given throughout the evening, and dark rooms were arranged for screen work. Here many may have seen for the first time a living heart in action. In the lower hall short lectures and demonstrations were given on different residual gases in vacuo. Tubes containing various fluorescent and phosphorescent materials, such as calcium tungstate and sulphide, dolomite, coral, foraminiferous marble, etc., were shown at work.

It was not until 12 o'clock that the greater part of this interested and appreciative assembly dispersed. The meeting was certainly a success, due doubtless to novelty, to a well-conceived initiative, and to a well-planned organization, but, more than all, to the great and growing interest that centres round the Roentgen ray.

THE ROENTGEN SOCIETY.

THE Inaugural Meeting of the season was held at St. Martin's Town Hall on the evening of November 5th. Amongst those present were:

LORD AND LADY CHELMSFORD.
RT. HON. LORD CRAUFORD, F.R.S.
THE DOWAGER LADY DASHWOOD.
SIR NATHANIEL BARNABY, K.C.B., and Party.
SIR WILLIAM CROOKES, F.R.S., and LADY CROOKES.
THE COUNT DE MANNIN.
THE VISCOUNT RAVEL DE H. DE MANNIN.
THE COMTESSE SHALE DE HAMEL DE MANNIN.

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Armould, L. A., Esq.
Ashburne, Ralph, Esq.
Atkinson, Leon, Esq., and Friends
Barlow, Eustace
Barnaby, Mrs.
Barnes, H. G., Esq., and Friends
Barnes, W. G., Esq., and Friends
Bartlett, Mrs.
Bass, Dr. Fred.
Batchelor, Mr. and Mr. A. W. G.
Batchelor, W., Esq.
Bateman, A. S., Esq., and Friend
Bateman, Hinton, Esq.
Bateman, Mrs.
Battye, Miss
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Bell, Jas., Esq., Civ. Eng.
Bell, Jeff., Prof.
Bergheim, F. S., Esq.
Bergheim, Mrs.
Berry, Mr. and Mrs.
Bidwell, Leonard, Esq.
Blackburn, Miss Ireland
Bonney, Rev. Prof., F.R.S.
Bourke, Surg. Lt.-Col. W., A.M.S.
Bourne, Miss, and Friend
Bowra, Miss
Boyd, Dr. Campbell
Brigham, Dr. H. E.
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Burns, Dr. Newton
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Cooper, P., Esq., and Friends
Constable, Syd., Esq.
Cossar, A. C., Esq., and Friends
Cossar, F., Esq., and Friends
Couper, P., Esq.
Cox, F. G., Esq., and Miss Cox
Cryne, Mr.
Cumberland, Miss
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"Daily News" (Representative)
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Davidson, Mr. and Mrs. Mackenzie
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Dobson, L., Esq.
Donovan, H. C., Esq., and Friends
Driver, Dudley, Esq.
Duncan, Nurse
East, Alf., Esq., R.I.
Eccles, W. Sottan, Esq.
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At 9 p.m. the Presidential address was delivered by Prof. SILVANUS THOMPSON, F.R.S., as follows :—

November the eighth, 1895, will ever be memorable in the history of Science. On that day a light which, so far as human observation goes, never was on land or sea, was first observed. The observer, Prof. Wilhelm Conrad Roentgen. The place, the Institute of Physics in the University of Würzburg in Bavaria. What he saw with his own eyes, a faint flickering greenish illumination upon a bit of cardboard, painted over with a fluorescent chemical preparation. Upon the faintly luminous surface a line of dark shadow. All this in a carefully darkened room, from which every known kind of ray had been scrupulously excluded. In that room a Crookes's tube, stimulated internally by sparks from an induction coil, but carefully covered by a shield of black cardboard, impervious to every known kind of light, even the most intense. Yet in the darkness, expressly arranged so as to allow the eye to watch for luminous phenomena, nothing visible until the hitherto unrecognized rays, emanating from the Crookes's tube and penetrating the cardboard shield, fell upon the luminescent screen, thus revealing their existence and making darkness visible.

From seeing the illumination by the invisible rays of a fluorescent screen, and the line of shadow across it, the work of tracing back that shadow to the object which caused it, and of verifying the source of the rays to be the Crookes's tube, was to the practised investigator but the work of a few minutes. The invisible rays—for they were invisible save when they fell upon the chemically painted screen—were found to have a penetrative power hitherto unimagined. They penetrated cardboard, wood, and cloth with ease. They would even go through a thick plank, or a book of 2000 pages, lighting up the screen placed on the other side. But metals such as copper, iron, lead, silver and gold were less penetrable, the densest of them being practically opaque. Strangest of all, while flesh was very transparent, bones were fairly opaque. And so the discoverer, interposing his hand between the source of the rays and his bit of luminescent cardboard, *saw* the bones of his living hand projected in silhouette upon the screen. The great discovery was made.

Here let me pause to say that at the preliminary meeting of our Society, when its constitution was framed and its Council chosen, it was determined, unanimously and cordially, to elect Prof. Roentgen as our first honorary member. I am happy to be able to announce that Prof. Roentgen has accepted that position. In a letter which I have received from him he tells of the regret with which he is prevented by his official duties from being with us at this gathering to-night. He bids me convey to the Society

which has named him as honorary member his cordial thanks for the honour we have desired to pay to him, and to couple with this message of thanks his best wishes for the prosperity and success of our Society. We had at one time hoped that Prof. Roentgen might have been able to send us for exhibition either the vacuum tube or the fluorescent screen with which he made his discovery. Unfortunately for our hopes, he informs us that most of his early apparatus, having been made by his own hands, was very simply and crudely constructed, and that much of it has been worn out or used up in the course of his researches, so that he is not able to send us any of those objects. To us, had this been possible, they would have been objects of priceless interest.

The fluorescent substance — the platino-cyanide of barium—which played so all-important a part in the great discovery, had long been known for its extraordinary power—a power it possesses in common with other fluorescent bodies, though to a higher degree than they—of shining in the dark when exposed to the invisible waves of ultra-violet light. That known property was doubtless the reason why it was selected by Roentgen in his investigation. But it was also known that the ultra-violet rays, also sometimes termed actinic rays, can produce another effect beside that of fluorescence; they can, for instance, produce photographic actions upon a sensitized plate. It was indeed thus that, forty years ago, Prof. William Allen Miller, of King's College, succeeded in mapping the invisible ultra-violet region of the solar spectrum—a region explored a few years previously by Stokes by use of a fluorescent screen. Naturally, when Roentgen found that the new rays could excite fluorescence, his very next inquiry would be whether, like the rays of ultra-violet light, they could also produce photographic action. Accordingly he exposed photographic dry plates to the operation of the Crookes's tube, and found himself able to record the silhouettes of those objects which at first he had seen projected visibly upon the screen. And so began the photographic process, which so keenly engrossed public attention as at first almost to overshadow the original discovery. It seems scarcely credible to-day that Roentgen's original discovery was so far forgotten in the photographic fever which set in that several persons who subsequently returned to the use of fluorescent screens gave themselves out as having made a new discovery. Prof. Salvioni's "cryptoscope," Mr. Edison's "fluorescope," and Seguy's recent "lorgnette humaine," are merely handy forms of fluorescent screen—convenient for the observer, no doubt, but scientifically differing in no whit from the simple screen of painted cardboard used by Roentgen.

No sooner, however, was Roentgen's discovery placed before the world than its immense importance was at once seen and acknowledged. No discovery of our time—or of any other time—has been followed by so immediate and universal an outburst of scientific activity. The revival of interest it has caused in the science of optics has been truly remarkable. The electrician seized upon it with scarcely less avidity. Every photographer, amateur and professional, found in it a new point of departure, and hastened to practise the black art of skiagraphy. But most of all did it appeal to the medical profession as affording a means of investigation of the most astonishing power, revealing in the living body deep-seated structures, which previously could only be diagnosed from the exterior or else explored directly by the probe or the scalpel of the anatomist. Very shortly also the Roentgen rays were discovered to possess electrical and chemical properties of a truly remarkable kind, giving scope to the physical investigator, and demanding his most acute discrimination.

Meantime the nature of the rays themselves gave ample food for speculation and research. To their discoverer they appeared to constitute a new kind of light, somewhat resembling, it is true, those ultra-violet waves of invisible light which were already known, but differing in several remarkable respects from them, and indeed from every known kind of light. In the first place they possessed an extraordinary power of penetration. To take a shadow photograph through a thick oak door, or to see a coin through a book as thick as a London City Directory, was indeed amazing; though these feats have long since been surpassed. Secondly, these rays differed from all known kinds of light in that apparently they could be neither reflected nor refracted. On the other hand they differed from all known kinds of electric discharge in refusing to be deflected by a magnet. In this respect they differed from those other and earlier discovered kinds of electrically generated phenomena, the cathode rays, which were made famous, twenty years before, by the researches of Sir William Crookes, and the Lenard rays, discovered now some four years ago by Prof. Philipp Lenard, of Heidelberg.

And here a word or two about those earlier discoveries may not be out of place. For, in the history of Science, nothing is more true than that the discoverer—even the greatest of discoverers—is but the descendant of his scientific forefathers, is always and essentially the product of the age into which he is born. Roentgen himself has

frankly avowed the ancestry of his discoveries. He himself has stated that, being aware of the existence of unsolved problems respecting the emission of cathode rays in and by an electrically stimulated vacuum tube, he had for a long time followed with the greatest interest the researches of Hertz and of Lenard, and had determined, so soon as he should find the necessary leisure, to make some researches of his own. Behind Roentgen, then, stand Lenard and Hertz; behind Hertz stand Crookes, and Varley, and Hittorf, and Sprengel and Geissler; and so back to Hauksbee, and Boyle, and Otto Guericke, into the beginnings of modern science as it emerged from the vain imaginings and occult mysteries of mediæval night.

To go no further back than twenty years, we may glance at the memorable researches of the veteran chemist—the pioneer in so many branches of chemical physics—whom we hail to-night, in health and undiminished activity, as one who has honoured our Society by also becoming one of its honorary members—I mean Sir William Crookes. He had found that from the negative pole or cathode of a vacuum tube—when exhausted to an extreme degree of perfection by an improved mercurial pump—there is emitted, under the stimulation of an electric spark, a species of luminous jet or ray, which travels in straight lines, can cast shadows on the tube wall, can excite brilliant fluorescence and phosphorescence in crystals and minerals on which it falls, and which also possesses several other notable and characteristic physical properties. When directed against a light vane, it can repel it with mechanical force; when concentrated by use of a cup-shaped cathode on an object, it heats it. When placed under the influence of a magnet, the jet or ray is itself deflected.

Crookes and the English physicists generally have regarded these emanations as a stream of negatively electrified molecules or atoms flying with great velocity from the cathode. On the other hand Wiedemann, Hertz, and the German physicists generally have preferred to regard the phenomenon as more akin to light, and therefore essentially as a process in the ether. Possibly both views are correct. Crookes has never denied that there may be ether processes or ether waves as well as molecular torrents. Wiedemann would be the last to dispute the presence of electrified molecules. The dispute narrows itself to the question which of the two is the essential. Probably both are essential if *all* the phenomena are to be explained. For these phenomena are varied and perplexing. Goldstein and Puluj have enriched science with sundry additional observations. The late Heinrich Hertz discovered that the cathode rays inside the tube could pass through a thin film of aluminium. Lenard, making use of this discovery, constructed a Crookes's tube with an aluminium window at its end, and so was able to cause the cathode rays, to which the glass wall of the tube is opaque, to pass out into the outer air. These Lenard rays are, like the internal cathode rays, capable of being deflected by a magnet; and they were found by Lenard to be capable of passing through sheets of metal, to produce photographic action, and to cause fluorescence. His fluorescent screen was however not platino-cyanide, but the less sensitive body "pentadecylparatolylketone." Lenard's success in bringing the cathode rays themselves to the outside of the Crookes's tube, and the existence of the long-standing dispute as to the nature of those rays, are two circumstances which might well stimulate other enquirers to examine further the phenomena attendant upon electric discharge in high vacua. In 1895 fluorescent screens were not things likely to be lying about accidentally, even in a laboratory where Crookes's tubes were being used. Hence Roentgen's discovery cannot in any sense be called accidental; it was the result of deliberate and directed thought. He was looking for something—he knew not precisely what. And he found it. Fortunate the discovery may well be deemed, but not fortuitous.

Nearly two years have elapsed since Roentgen's discovery was made public. During that time thousands of workers all over the globe have busied themselves in the new branch of science thus opened out; and of these thousands a few have been able to make contributions of permanent value to science. Given the discovery, it is easy to follow out its developments:—

> "All can raise the flower now
> Most have got the seed."

As our Society is composed of those who are desirous of aiding and following out that development, it is germane to our purpose that a brief review of that which has been achieved should be made.

Let me deal first with improvements in apparatus. No other source of Roentgen rays than the Crookes's tube has yet been discovered; but much has been done to perfect the tubes themselves. Roentgen himself had concluded from his experiments that the place of origin of the rays was the glass wall upon which the internal cathode rays impinged. This was indeed true in the case of his tubes, wherein the discharge was directed against the glass, with the result of heating, and, in extreme cases, of softening the glass. The circumstance that the walls themselves fluoresced at

this point, led to the mistaken though natural suggestion that visible fluorescence played some part in the generation or emission of the rays. Experiment, however, showed, firstly, that highly fluorescent materials when substituted for glass gave inferior results, while the substitution of a metallic surface or target to receive the impact of the cathode beam greatly improved the emission of Roentgen rays. The less fluorescence the better, was the true inference. Several English workers arrived about the same time at this conclusion, foremost among them Mr. Herbert Jackson, whose form of focus tube with an oblique target or "anticathode" of platinum has so far held the field as the most effective form of tube. The immediate result of this improvement—which has since been adopted widely in France, Germany, and America—was an exceedingly great gain, not only in the copiousness of emission of the rays, but also in the definition of the shadows, whether as viewed on the screen or as registered by photography. The fuzzy and indefinite appearance of the earlier skiagrams at once vanished, while the new tubes excelled in penetrative power. It was found in my laboratory that the material of the emitting surface was of some moment, those metals which have heaviest atomic weight being better than those of lighter. Uranium was better than platinum: platinum than iron or copper. This law has quite recently been confirmed by Prof. Roìti, of Florence. Tubes having two cathodes focussing upon one target have been devised for use with oscillatory currents; such are not, however, to be preferred in general. To vary the degree of exhaustion, tubes are now in some cases provided with an auxiliary chamber, containing, as suggested by Crookes, potash or hydro-ozonised palladium. On applying gentle heat the vacuum is reduced.

Tesla has produced some remarkable results with tubes containing but a single electrode, and excited by an apparatus to which reference must be made presently. In Italy, Professors Villari, Righi, Roìti, Battelli, and others, have examined most exhaustively the dependence of the physical phenomena upon the construction of the tube. Our member, Mr. Campbell Swinton, has elucidated several points in the construction of tubes which, prior to his investigations, were entirely obscure. In London, Paris, and Berlin the opticians have vied to produce tubes of the best and most effective forms.

Simultaneously with the improvements in the tube others have been undertaken upon the other appliances. Owing to the inferiority of the samples of barium platinocyanide which were in commerce at the beginning of 1896 other substances now known to have no advantage were suggested as improved substitutes. Mr. Jackson still prefers to work with the hydrated platino-cyanide of potassium, which at the time was so greatly superior to the barium salt then procurable. But the difficulty of keeping this material hydrated, and the circumstance that at its best it is scarcely superior, if superior at all, to the best samples of the barium salt, have conspired to make the majority of us prefer the latter. In like manner Mr. Edison announced that he had found tungstate of calcium—a material already known under its mineralogical name of scheelite as a fluorescent body — to be brighter than barium platinocyanide. It has, indeed, the great merit of cheapness, but is inferior in luminescent quality, and has the disadvantage of giving an annoying persistence of images. Better than simple calcic tungstate is an artificial preparation of that material containing a little manganese tungstate in solid solution.

In photographic materials much progress has been made. The improvements in the tubes reduced the time required for exposure from minutes to seconds. To further reduce the exposure many suggestions have been made. Special films have been devised by the photo-chemists. Films of extra thickness were suggested by Oliver Lodge as better than those of the usual substance. Double and quadruple films are in use for special cases. These highly penetrative rays can, indeed, so long as no glass intervenes, simultaneously imprint skiagrams on ten dozen superposed sensitive films. Other workers have essayed to reduce the time of exposure by the use of a luminescent sheet superposed upon the sensitive plate so as to increase the photographic action by the actual light emitted from the prepared surface. But success in this direction—which certainly succeeds in giving to the rays a perhaps centupled photographic effect—has hitherto been accompanied by a sacrifice of definition; for the superposed luminescent sheet always imprints a certain undesirable granulation upon the photographic image. One of our members, Mr. Greenhill, has lately made some improvements in this matter.

From the first it was an open question what was the best way of exciting the Crookes's tubes. Roentgen himself used an ordinary induction coil; and an induction coil capable of giving a spark of a few inches length has been the source employed by the most successful investigators. One of our members, Mr. Lewis Wright, has lately published a careful work dealing with this subject. The particular form of coil developed during long years by

Mr. Apps has never till now been beaten. I say so advisedly after seeing the performance of coils made by the chief makers of France and Germany. At one time an opinion was afloat—originated by whom I know not—that Crookes's tubes were best excited by using with the induction coil a second oil-immersed coil arranged in the manner devised by Tesla, with a spark-gap for the production of electric oscillations of high frequency. The experience of almost all who have tried this combination is quite adverse to its supposed benefits. The ordinary Crookes's tubes used in this way with a Tesla oil-coil gave worse results, not better. The oscillatory discharge blurs the definition; and, worse than this, speedily overheats and destroys the tube. The amateur electrician will do well to let the Tesla oilc-oil arrangement severely alone.

But in saying this let me not do injustice to one whose work in this matter is of the highest scientific merit. For Mr. Tesla has designed for use with the high-frequency discharge special tubes that have, so far as I am aware, absolutely surpassed all others in the results they yield. When recently visiting Mr. Tesla's laboratory in New York I had the rare opportunity of seeing for myself what splendid results he has attained; and as he has kindly sent for exhibition to our Society not only some of his skiagrams showing soft tissues with remarkable delicacy, but also one of his new instruments for the production of the oscillatory discharge, you will have the best opportunity of forming your own judgment as to the value of his work. He has, in brief, devised a new kind of induction coil, based upon the principle of resonance, by which, without any energy-wasting spark-gap, and by the use of relatively few turns of wire, he can take current straight from the electric supply mains and transform it into high-frequency discharges. The emission of Roentgen rays from one of his tubes so excited, is so intense that, standing fifty feet away from the apparatus, one can still obtain on a luminescent screen the shadow of the bones of one's hand.

For screen work, where steadiness of illumination is eminently desirable, there are some advantages in using as electric source a Winshurst's influence machine. Possibly we may during our coming session have some opportunity of discussing this very interesting and practical question.

Turning from improvements in appliances to advances in the results attained and in the applications of the discovery, we are confronted with a marvellous record of progress.

Excepting only the introduction into surgery by Lord Lister of antiseptics, and the discovery of anæsthetics, no discovery in the present century has done so much for operative surgery as this of the Roentgen rays. The first great application has been the use of the rays by the surgeon for the diagnosis of fractures and dislocations, the study of bone disease, and the detection of foreign bodies in various parts of the human frame. To cite only the leading cases in which surgery has benefited within the United Kingdom would be to name the leading members of our Society, for it is they who have been chiefly instrumental in bringing our Society into existence. To particularize might be invidious, but none will object to my mention of the name of Dr. Macintyre, of Glasgow, whom we had hoped to see amongst us to-night, and who was one of the earliest and most successful practitioners of the new art. His kinematographic application, to show the actual motions of the bones in a living creature, is of singular interest. In the United States the most remarkable achievement yet reached is the successful production in a life-sized skiagram of the entire skeleton of a full-grown living woman—a most remarkable and striking picture shown on our walls to night—by Dr. W. J. Morton of New York. Even the heart and other soft tissue organs are visible. We may almost adopt as a prevision of Roentgen's discovery Shakespeare's words:

"You shall not budge—
You go not till I set you up a glass
Where you may see the inmost part of you."

Coins in the larynx, shots and needles in the hand, and bullets in the brain, have all been seen, skiagraphed, and localized. Vesical and renal calculi have been observed *in situ*: even the progress of tubercular disease in the lungs has been rendered evident. To watch the motions of the living heart is now an everyday observation. An admirable summary of the surgical, anatomical, and pathological applications of the Roentgen ray has been so lately published in the "Archives of the Roentgen Ray," by one of our members of Council, Dr. Hedley, that no detailed notice of these things is here needed. Dr. Hedley has also described the more restricted applications to physiology and therapeutics: applications doubtless soon to be further extended.

The art of accurately localizing foreign bodies embedded in more transparent tissue has claimed the attention of many able surgeons. By taking two views in different directions it has been theoretically possible to ascertain the exact position of an object. Long formulæ for calculating the depth from the projected shadows have

been worked out. But quite recently all this complication has been rendered unnecessary by the simple and ingenious apparatus invented by one of our active members of Council, Mr. Mackenzie Davidson. With this apparatus any intelligent person can at once localize to within the hundredth of an inch the exact position, say, of a needle in the hand or foot; the complicated geometry of oblique projection being simplified down by the instrument itself, and reduced to the application of callipers and a divided scale. This is an advance none the less important in that it is so essentially practical.

But if the Roentgen ray has brought to the medical practitioner such a powerful aid, it has also brought new and bewildering problems. Soon after the invention of the focus tubes had furnished powerful sources of Roentgen rays, it was noticed that exposure to them frequently resulted in severe local inflammation of the skin, accompanied in some cases with destruction—at least temporary—of the hair, which fell out, leaving bald patches. One of my own assistants suffered for some six weeks from a bald patch above the ear, as the result of an attempt to skiagraph his skull. Many have lost the small hairs from their hands. One instance is reported of a baldness which threatens to be permanent. It is disputed whether this effect is a direct effect like sunburn, whether it is indirect and due to the chemical action of ozone generated by the ionizing of the oxygen of the air, or whether, finally, it is an electrical effect. Our hon. secretary, Dr. Walsh, has found that it may occur even deep-seated within the tissues. Some assert that this curious dermatitis is prevented by interposing a sheet of aluminium. If this is true it would seem that the effect is electric in its origin. On the other hand, cases are known in which the inflammatory symptoms have occurred on the side of the body furthest from the Crookes's tube. Some persons are much more sensitive to this effect than others: some apparently wholly insensitive. The existence of this singular affection has given rise to the suggestion that the Roentgen rays may possibly be found to have some useful pathological application for the treatment of such diseases as leprosy—possibly even for tuberculosis. The suggestion that they might be useful as a destructive agent to kill bacteria, has led to various researches, but so far with an entirely uncertain result.

If it were possible that the Roentgen rays which penetrate tissues opaque to light should have any direct effect in nerve stimulation, then the door would be opened to the hope that by their aid sight might be, in some cases, artificially given to the blind. This, indeed, has been investigated already in a number of cases, but hitherto with no real success. Where blindness is due to destruction of the optic nerve such hope is absolutely vain. And if, as is the commonly received opinion, the retina and the percipient nerve structures of the eye are not in the normal healthy eye affected by or sensitive to the Roentgen rays, what reason have we to suppose that in the diseased or long-disused eye these nerve structures should possess that property? The question is ably discussed by Dr. Walsh in his recent book on "The Roentgen Rays in Medical Work." Certain it is that almost every case examined has given negative results. Murani's experience is against the possibility. Nevertheless, there is something to be said on the other side of the question. Prof. Brandes has found, and Prof. Roentgen has confirmed the result, that under certain circumstances the retina of the normal eye does possess a faint perception for Roentgen rays. If a well-excited focus tube is perfectly screened with aluminium screens, and the observer is in perfect darkness, he may be conscious of a luminous sensation when he turns his eyes in the direction of the shielded tube; and if a piece of platinum, with a narrow vertical slit in it, is placed over the pupil, he may distinguish a vertical luminous stripe. This may not occur with every individual. Roentgen attributes it to the slight fluorescibility of the retina itself. Further than this, Dr. Louis Bell, formerly of the Johns Hopkins University, reported a case where an intelligent man who had become blind from paralysis many years before was able, though totally insensitive to lamps of all kinds and to the brightest electric sparks in the air, to distinguish the form and position of a Crookes's tube, and could even distinguish letters cut in stencils placed over the tube. The interposition of either cardboard or metal sheets cut off the rays that were thus operative. Hence it is probable that the operative rays were not actually Roentgen rays, but others closely akin to them, emitted from the tube.

Even though it would appear that the Roentgen ray gives no prospect of restoring of sight to the blind in general, yet, if only in one case in a thousand such partial success as that reported by Dr. Bell is attained, the subject is amply worthy of the fullest investigation.

Time precludes me from alluding in any detail to the applications of the rays in botany, in mineralogy, and in metallurgy. All the world knows of their application to the detection of false gems, to the discovery of adulteration of textile fabrics by mineral substances mixed with the sizing materials so as to add weight, and to the examination of the contents of packages and parcels supposed to

contain jewellery or explosives. The latest metallurgical application is that of Messrs. Heycock and Neville to the study of the properties of the alloys of gold and sodium, a study which already explains the long-standing mystery why the introduction of small quantities of a foreign metal reduces so greatly the electric conductivity of the metal.

Turning back finally from the applications of the rays to the physical problems presented by them, we find that, while there is much progress to chronicle, there is also opening out a vast prospect of problems awaiting solution.

Allusion has been made to the electrical and chemical properties of the rays. They are found to have a dissociating, or, more strictly, an ionizing, effect upon the molecules of gases through which they pass; with the result that electrified bodies placed in an atmosphere thus affected are discharged. This property at first led to the idea that the rays themselves converted non-conducting substances into conducting substances. But it has been shown that whenever the rays cross a gaseous medium in the neighbourhood of electric conductors in such a direction—whether they impinge against the conductors themselves or not is immaterial—as to cross the lines of electric stress in the medium, they produce an electric discharge; in other words, by ionizing the molecules of the medium they permit that process of atomic interchange to go on in which electrolytic conduction is supposed to consist. A masterly *résumé* of the relation between Roentgen rays and ionization, including an account of the researches of J. J. Thomson, Perrin, and Villari, has lately been given in the "Revue Générale des Sciences" by M. C. E. Guillaume. He shows reason for thinking that the singular action of the rays in producing skin inflammation and depilatory effects may be traceable to this ionizing property.

Further, it is now generally admitted that the Roentgen rays are themselves not homogeneous—that they are of many different kinds differing in penetrative power, the quality of the mixture depending on the state of the vacuum and on the degree of electric stimulation, as well as on the form of the tube and the nature of the emitting surface. The relation between the cathode rays and the Roentgen rays has been investigated, and important contributions to knowledge have been made by our valued member Mr. Campbell Swinton, by M. Perrin, and by several Italian investigators. Professors Cox and Callendar, of Montreal, have investigated the velocity of propagation of the rays.

Many speculations have been put forward as to the physical nature of the rays themselves. It is held by Crookes, Tesla, and others, that they consist of flights of minute atoms or hyper-atoms. Prof. Elihu Thomson has followed this interesting speculation into its logical consequences, which involve a radical change in our ideas respecting the non-transmutability of the elements. On the other hand, hypotheses have been put forward that they are merely an extreme sort of ultra-violet light, and consist of transverse waves of excessively minute wave-length. Jaumann, and apparently Roentgen, regard them as due to longitudinal vibrations; while Sir George Stokes has put forward the view that they may be transverse waves, not in regular trains but consisting of innumerable solitary waves. In the July number of the "Archives of the Roentgen Ray" I have given a brief summary of the present state of these theories.

There seems, however, to be a chance of arriving at least at a decision as to whether or not they are of the nature of waves. If they are, then one may expect some of the laws of wave propagation to apply to them. Amongst these laws is that of the reciprocity of absorption and radiation, known as Kirchhoff's law. Now Roentgen concluded from his early experiments that the absorptive power (or opacity) of a substance for the rays was approximately proportional to its density. Dewar gave reasons for correcting this view, and suggested that atomic weight rather than density governed absorption. Dr. Gladstone and Mr. Hibbert have followed this up with great perseverance, and shown the relation to be real and very close. Some of the results of their research in the form of photographic records of relative opacity are exhibited here to-night. If, then, the law of Kirchhoff is applicable, the substances of greatest atomic weight ought also to be the best emitters. This is precisely what I found fifteen months ago: uranium, the metal of greatest atomic weight, the best. Now that Roïti has confirmed my result, I think I may fairly claim the fact as at least *primâ facie* evidence of the wave-nature of the rays. Elsewhere I have propounded another criterion, based on the electro-magnetic theory of light; for if it were found that aluminium when cooled in liquid oxygen becomes more opaque to the rays, at the same time that its electric conductivity is increased, this would confirm the same view.

Another wide field of research opened out is the discovery by Becquerel, by Dr. Dawson Turner, and by myself of other kinds of rays of a closely analogous kind. That the salts of uranium, and glowworms, and fireflies, and sticks of phosphorus should be able, without any

electric stimulation, to give out rays that will produce photographic action through substances that are opaque to every known kind of light, is very suggestive. But these are not Roentgen's rays, and obey different laws. The latest contribution to this part of the subject is the elaborate investigation of Dr. W. J. Russell, who has found innumerable substances, wholly unsuspected hitherto, to be capable of affecting photographic plates in the dark.

It is clear, then, that our little Society has an abundant field before it to engross the activities of its members, not only for the approaching winter, but, I trust, for many years to come. Already there are three journals established —one in England, one in Germany, one in America—for the publication of observations and discoveries connected with the Roentgen rays. Every month sees formidable additions made to the literature of the new science. The pioneers have opened the way into the wilderness; they are now being followed by those who will occupy the new territory, complete its survey, and map out its features. Not until every corner is explored and charted will the work of our Society be ended. But, while life is short and art is long, science expands without limit or term.

It is impossible to conclude this imperfect review of the subject without reverting once more to Prof. Roentgen and the scene of his work. The little town of Würzburg, with its 55,000 inhabitants, boasts of a University which it has provided with an array of separate buildings or Institutes equipped for the study of the various sciences, and it is in the handsome building of the Institute of Physics that Prof. Roentgen lives and works. The great city of London, one hundred times the size of Würzburg, has not yet provided its University with a single Institute for the study either of physics or any other of the physical sciences. But whether working in a modern laboratory equipped by the foresight and at the expense of an enlightened municipality or state, amid the intellectual surroundings of University life, or whether compelled by force of circumstances to experiment in isolation and obscurity, the scientific worker who patiently tracks out the unexplored pathways of Nature is certain, sooner or later, to succeed in penetrating a little further into the mysteries of the unknown. His work, however unambitious, is not in vain.

"Nature never did betray the heart that loved her."

A vote of thanks, proposed by Sir Wm. Crookes and seconded by Dr. Gladstone, F.R.S., was enthusiastically accorded.

The programme was then continued as below :—

9.45 p.m.—Lantern Demonstration by Mr. Greenhill, Dr. Low, and others, in Small Hall (adjoining Main Hall).

10.30 p.m.—Second Lantern Demonstration.

Screen Room, for Demonstration of the Living Body, under J. Moore, F.R.C.S., and Mr. Webster, all the evening (in small parties); Mr. Webster's 20-in. spark Apps-Newton coil being used.

9.45, 10.15, 10.45 p.m.— Small Hall on Ground Floor next Entrance. Demonstrations of various Exhaust Tubes, by Mr. Isenthal and Dr. Fenton. There was a 10-in. spark coil and apparatus kindly lent by the Earl of Crauford. Mr. Cossor showed tubes in action containing various fluorescent and phosphorescent materials: Calcium tungstate, Rubies, Dolomite, etc., etc.

Exhibition of Photographs, under Messrs. Snowden Ward and Mackay. Large Hall.

Dr. Gladstone, F.R.S., showed Photographs of Alkaline and other Metals in order of their power of absorbing Roentgen Rays (with Mr. Walter Hibbert).

Mr. F. H. Neville, M.A., F.R.S., Cambridge—Microskiagrams of Sections of Sodium-gold Alloys, showing internal constitution of Alloys.

Mr. F. C. Abbott, F.R.C.S., exhibited Photographs of Bullets taken at the seat of the recent Græco-Turkish war.

Mr. Gifford—Early Work.

Mr. Gardiner—Biological and Conchological Objects.

Mr. Griffith Wilkin—Skiagrams of Ear.

Dr. Norris Wolfenden—Natural History Objects.

Dr. Walsh—Comparison of Bloodless and Turgid Hands.

Mr. Greenhill—Illustrating Short Exposures.

Numerous other Photographs of general and special interest by Messrs. Glew, Ogston, Ernest Payne, A. A. Campbell Swinton, William Webster, Sir Gervas Glyn, Bart., and Drs. Barry Blacker, Hall-Edwards, W. Cotton, F. H. Low, Newman, Nathan Raw, Coke Squance, G. Smith, H. Bateman, W. Severn, and others.

Dr. Morton (New York) showed a Full-Length Figure taken at a single exposure, a reduced copy of which appeared in the last issue of "The Archives."

Exhibition. Large Hall. (Under the charge of Dr. Hedley.)

Mr. Mackenzie Davidson and Mr. Hall-Edwards each demonstrated New Methods of Localizing Foreign Bodies. (For the former *see* p. 32, for the latter *see* "The Photogram," Nov., 1897.)

Dr. Hedley—a Stereoscope, showing amongst other objects an injected human brain.

Dr. Barry Blacker—a Motor Interrupter, etc.

Mr. Ernest Payne—Coils, Interrupter, and Apparatus.

The President showed a new pattern of Induction Coil, invented by Mr. Nikola Tesla, giving high-frequency oscillatory discharges direct from any ordinary electric supply with small expenditure of energy.

Max Levy, M.D., Berlin—Fluorescent Screens for shortening exposure; Plate and Film Boxes for reception of Plates, etc.

Dr. Walsh—Transparency: Plates to illustrate Book, "The Röntgen Rays in Medical Work."

Messrs. Binko & Co.—"Dolphin Contact Breaker," and other Apparatus.

Mr. A. C. Cossor—Tubes of own manufacture.

The Electrical Company—Screens, Tubes, Coils, Contact Breakers.
Messrs. Fuerst Brothers—Special Roentgen Ray Sensitive Plates.
Lithanode Electrical Storage Company—Various Batteries.
Messrs. Maw, Son, & Thompson—Roentgen Apparatus, etc.
Messrs. Miller & Wood—Induction Coils, Tesla Apparatus, etc.
Messrs. Newton & Co.—Coils, Tubes, Current Meters, etc.
Messrs. Rebman & Co.—"Archives of the Roentgen Ray."
Mr. W. K. Schall—Accelerating Screen, Motor Interrupter, Rheostats, Actinometer for testing Tubes, etc. This useful instrument consists of a mahogany case, the interior of which contains twelve squares of tinfoil, of various thickness, and each square is provided with a leaden figure. The thinnest square bears the figure 8, and so on. The case is to be held between the tube and the fluorescent screen; the higher the value of the figure still visible on the screen the greater the penetrating power of the tube, and *vice versâ*. The quality of different screens can also be so compared.
Mr. Glew showed a method of reviving focus tubes. Inside the narrow stem of the tube a few pieces of very fine soft iron wire (each piece of wire having a thin coating of resinous matter) are sealed up when the tube is fully exhausted. When the vacuum gets too high one of these small pieces of wire is selected, and brought, by means of a magnet, into a convenient part of the narrow stem; a spirit lamp is then placed underneath this piece until the resinous coating of the wire is decomposed. Of course the focus tube is connected to a coil during this disengagement of gas, so that the result can be readily watched, and the process stopped at any stage by removing the lamp. A series of photographs of anode and cathode phenomena at different pressures were shown, the vacuum having been controlled by the above method.

The PROGRAMME OF MUSIC was as follows:—

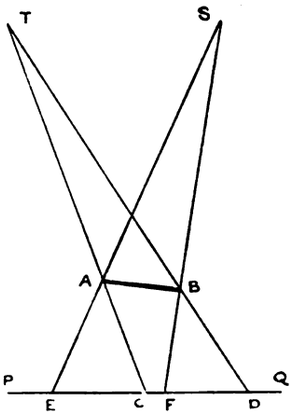
Song—"Il Sogno" (Mercadante)—Mr. William Webster. Violoncello Obbligato—Mr. Prosper Burnett.
Songs—(*a*) "Du bist wie eine Blume" (Schumann); (*b*) "Mutter, Mutterchen" (Helmund)—Miss Cordelia Grylls.
Pianoforte Solo—"Liebestraum" No. 4 (Liszt)—Mr. Septimus B. Webbe.
Songs—Mr. Henry Piercy.
Violoncello Solo—Mr. Prosper Burnett.
Song—"Lovely Spring" (Becker)—Madame Marian McKenzie.
Song—"The Lass with the delicate air" (Arne)—Miss Cordelia Grylls.
Song—"Largo al factotum" (Rossini)—Mr. William Webster.

LOCALIZATION AND MEASUREMENT OF HIDDEN BODIES BY THE AID OF ROENTGEN RAYS.

By ERNEST PAYNE, M.A.

IN the following article I propose to describe some of the apparatus and methods which I have tried and found useful for the above purpose.

Let us first consider a theoretical case. Referring to Fig. 1: let A B be a hidden object, the size and position of which we wish to know. If we take a radiograph with a tube at T, we shall obtain a shadow C D on a plate P Q, placed below the object; if we then move the tube to another position, S, we shall obtain another shadow E F. Then if we draw lines from T to C and D, the extremities of the first shadow, and from S to E and F, the extremities



of the second shadow, T C and S E will cut one another at A, and T D and S F will cut one another at B. Conversely, therefore, if the positions S and T are given together with the dimensions of the shadows, we can determine the position and size of A B.

In actual practice graphic methods can be employed, the drawings being made full size or to scale, so that no trigonometrical calculations are needed, and the dimensions can be taken direct from the drawing.

It will be necessary to note the position of the plate in each case with regard to the tube and with regard to the body containing the hidden object; and the result will depend upon the care with which these observations are made.

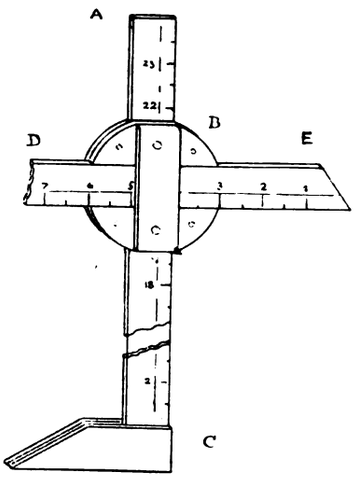
In many cases, such as radiographs of the hand, the tubes can be placed vertically above the opposite edges of the plates, and at a fixed distance above them.

An arrangement for keeping the hand in position while changing the plate was described some months ago in one of the technical journals. A thin board was employed, slightly raised from the table, so that the plate could be slid in below it without requiring the hand to be raised. I have not been able to find the article, but I believe it was written by Professor Elihu Thompson.

For measuring the positions of the plates with regard to the tubes and the body or limb, as the case may be, I often use a rule, shown in Fig. 2, consisting of two strips of wood sliding at right angles in a block B, having inches marked upon them. The vertical and horizontal distances

are both taken at the same time by the arms A C and D E respectively.

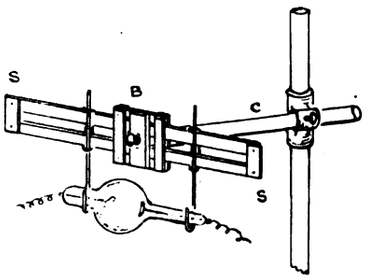
Marks may be also produced upon the plate by employing small pieces of metal, which are placed beside or below



a certain point or mark made on the skin at the time of taking the radiograph, in order to facilitate the subsequent superposition of the two shadows, which will be placed one over the other, so that these marks coincide.

Another method for showing the position of the limb with regard to the plate is to fasten a small piece of sheet metal to the skin, on the side next the plate, which will thus cast a shadow on each plate exposed. If a line is required across the plate a piece of fine covered wire may be used; this should be previously moistened with ink or other stain, and then placed across the plate, or fastened round the limb; the ink will make a line on the skin, while the wire will at the same time cause a corresponding shadow on the plate.

In order to shift the tube easily from the position S to T (Fig. 1) I use a sliding tube holder, shown in Fig. 3.



S S is a sliding bar, composed of two thin strips of wood fixed together at each end, and sliding to and fro in a block B, that is fixed to the cross-piece C, which again fits into a block sliding up and down on the vertical support resting in a heavy base on the table or floor. The tube is held in two glass hooks, fixed to the sliding bar by two elastic bands, through which the glass will not easily slide. I have found this method of holding the tubes very useful, as it is adapted to every form of tube, and there is no risk of the tube slipping or being pulled out of its place by the wires from the coil. The distance through which the slide is moved is noted from divisions marked on one of the slide bars.

(To be continued.)

Brighton.

In an article by James Mackenzie Davidson, M.B., and W. S. Hedley, M.D. (*Lancet*, October 16th), entitled "A Method of Precise Localization and Measurement by means of Roentgen Rays," the following procedure is laid down:—

Two wires at right angles to each other are placed upon the photographic plate, film, or paper. The Crookes's tube is then placed with its anode at a measured distance from the plate and exactly perpendicularly to where the wires cross. The tube is fixed in a holder which slides in one plane. Further, one of the cross wires must be in exactly the same plane as that in which the tube is to be displaced. The wires being painted over with some pigment the part to be photographed is placed on the plate, and carries with it a mark of the cross wires. The tube is then displaced to a measured distance to one side of the perpendicular and an exposure given, then to a corresponding point on the other side of the perpendicular and another similar exposure given. The resulting negative shows double images from the two different points of view. A further precaution is necessary—viz., to mark one quadrant of the plate and the corresponding quadrant on the patient's skin.

The negative having been developed, fixed, and slightly washed, is at once placed on a horizontal stage illuminated from below by a suitable reflector (an arrangement similar to a re-toucher's desk). The negative may be placed with the gelatine surface upwards, or downwards if the glass is not too thick. In the case of celluloid films it is most convenient to place them downwards. The negative is adjusted so that a perpendicular dropped from a notch in a horizontal scale falls upon the point where the shadows of the wires cross. On each side of it another notch is made at the exact distance and height that the anode of the Crookes's tube occupied in the two exposures. A fine

silk thread is then passed through each lateral notch, and a small lead counter weight is attached to one end of each thread, while the other is passed through the eye of a fine needle. The needle is weighted with lead so that its eye lies flat on the surface of the negative. In short, these two silk threads represent the path of the X rays, so that if each needle be carefully placed upon a corresponding point in each shadow it follows that the point where these threads cross marks the position occupied by the corresponding part of the actual object. Further, its distance can be measured perpendicularly from three planes—from the horizontal which gives its depth, and from the two planes represented by the shadows of the cross wires. By measuring any other desired corresponding points the precise size, position, and direction of the object can be determined, and remembering that the cross wires have left their mark on the patient's skin we can at once from these data give the surgeon all the information he can possibly desire.

Notices of New Books.

The Roentgen Rays in Medical Work. By DAVID WALSH, M.D.Edin., Physician Western Skin Hospital, London; Hon. Sec. Roentgen Society, London. With an Introductory Section upon Electrical Apparatus and Methods by J. E. GREENHILL. (Ballière, Tindall, & Cox, London. 1897.) 6s.

THIS book is well timed, ably written, and sufficiently comprehensive. It fully covers the ground indicated by its title, taking the latter in its fullest sense. Surgery, dental surgery, obstetrics and gynæcology, legal medicine, anatomy, physiology, and veterinary uses are fully and even elaborately dealt with from the point of view in question. A method devised by the author of mapping out the coarser fissures of the skin by first loading them with opaque substances is illustrated in the frontispiece, and this forms one of fifty-eight excellent engravings which alone, even without the instructive letterpress that accompanies and explains them, are almost sufficient to indicate the present status of "clinical skiagraphy."

Mr. Greenhill's part of the work occupies about one-third of the volume. So far as it is possible (and the writer seems to have proved it possible) to condense the eight subjects of which he treats into less than thirty octavo pages, this is a complete exposition of methods and apparatus. "The Sources of Electricity," "The Induction Coil," "The Crookes Tube," "The Exhaust Pump," "The Fluorescent Screen," "Photography," "Stands and Other Accessories," "Practical Application," "Theory," all come under review, and the survey is altogether a marvel of compression, without sacrificing clearness, completeness, or even detail. In the introduction the author points out that the interpretation of X ray results requires "not only practice, but also the knowledge of many co-ordinate facts," and that therefore when the "professional skiagrapher" is also a trained medical man he is so far in a comparatively favourable position to give a skilled reading of the skiagraphic record. With reference to opinions quoted further on in this introduction, it may appear to many as it does to the writer of this notice that it is easily possible to under-estimate the importance of a knowledge of physics and electricity even in the exclusively medical application of the Roentgen rays.

Bibliography of X Ray Literature and Research, 1896-1897. By CHARLES E. S. PHILLIPS. ("The Electrician" Printing and Publishing Co., Ltd., London.) 5s.

SUCH a work as this had become almost a necessity. The vast and scattered literature of the X ray was already beyond the ken of even its most industrious student. This little volume (one of "The Electrician" Series) alphabetically names the various books, pamphlets, and papers bearing on X ray research, up to March, 1897; and this list is supplemented by a shorter one bringing the former up to date. But it aims at being something more than a mere "glorified book catalogue." It *is* more, and much more. Its historical retrospect, practical hints, and notes in connection with the Bibliography raise it far above any mere "miscellaneous reference list."

Description of Plates.

PLATES XXXI. AND XXXII.

Three skiagrams are here represented, taken respectively from the hands of a healthy adult, an acromegalous subject, and a gouty man. The last was an exposure of five seconds, done by covering the plate with several sheets of zinc, and suddenly removing them when the tube was judged to be working at its maximum efficiency.

In the first, the cancellous tissue of the carpal bones and that in the extremities of the metacarpals and phalanges stands out as a fine network in contrast with the compact tissue of the two latter. The intercarpal articulations, even that between the trapezium and trapezoid, are quite distinct. This partial exception is explained by the latter bone being overlapped by the former. The wide gap intervening between the cuneiform and the place occupied by the triangular fibro-cartilage may also be noted.

In the second figure the osseous structures are enlarged generally, but not uniformly, growth, it will be observed, having taken place more actively at the distal ends of the index, middle, and ring fingers; the contour of the soft parts of those digits shows that they have also participated in this increase. From notes supplied by Dr. Stone Smith, to whom we are indebted for the radiogram, it appears that the patient, a gentleman, had observed progressive enlargement of his lower jaw, as well as of both hands and feet, for five years. He was forty-two years of age, and enjoyed excellent health, his mental activity being in no way impaired. The normal fingers at the upper left corner are those of Dr. Scott, and have been inserted for the sake of comparison.

In the third representation changes of a very gross character can be seen.

Not only have several joints been destroyed by infiltrating masses, presumably of urate of soda, and in more than one instance dislocation has occurred, but also a condition allied to osteo-porosis is evident in some of the metacarpals and phalanges, especially those of the little finger.

The thenar eminence appears as a white cloud between the thumb and middle finger.

In order to insure a uniform representation of the bones of the carpus and fingers it is often well to reduce the exposure of the latter to the X rays by interposing a metallic sheet at frequent short intervals, as the deeper-seated bones require a longer exposure than do those less thickly clad with soft parts.

PLATE XXXIII.

A CASE OF ACROMEGALY.

By T. H. IONIDES, M.B., F.R.C.S., Honorary Surgeon Hospital for Women, West Street, Brighton; Assistant Surgeon Alexandra Hospital for Children.

E. D., aged forty-three, up to the age of twenty-one had excellent health, but in the next two years became anæmic, and continued so in spite of treatment, at the same time feeling perfectly well. At the age of twenty-five she became very fat and disinclined to work, but still her hands were of the same size as before. She looked about ten years older than she was. Her appetite was voracious. Her hands and feet and head began to enlarge ten years ago, and she has gradually been getting larger and larger gloves and boots.

The photograph will show the massiveness of the features, and the prominence of the eyes, supra-orbital ridges, and glabella. The lower teeth project beyond the upper, and there is a distinct thickening of the dental margin. No trace of the thyroid gland is to be felt.

The sternum is thrown forwards and the lower half sharply bent backwards, and the dorsal curve of the spine very excessive, so the antero-posterior diameter of the chest is very large. The costal cartilages are ossified, with marked lipping and ridging at the costo-sternal articulations.

In the upper limbs there seem to be no changes till you come to the hand. Here the photograph and the radiogram show the changes clearly. There is no anthritic creaking. The phalanges seem enlarged, also the lower end of the radius and ulna; that was the same in both hands. Abdomen is very prominent. There is marked thickening of the iliac crests; tibia and fibula in both legs very thickened. The feet are enormous, but feel as if the enlargement depended mainly on the subcutaneous tissue; but this is not entirely the case, as the radiogram shows considerable enlargements of the ends of the bones.

Improvement under the combined use of pituitary and thyroid extract.

This case is of interest, as about two years ago a similar case was published in the *British Medical Journal*, with radiograms, in which there were no bony enlargements to be seen. Yet we have always been taught that the enlargements found in these cases are osseous and I think that the latter point is clearly shown in the present instance.

PLATE XXXIV.

(*a*) BONY ANCHYLOSIS OF KNEE.

Inflammation of the knee joint, resulting from an injury eight years ago. It has twice, for a long period, been fixed in plaster of Paris. There has never been any operation.

(*b*) ANCHYLOSIS OF ELBOW.

PLATE XXXV.

A CASE OF HIP DISEASE.

Boy, aged five. Showing result of disease in right hip. Erosion about head and neck of femur; dislocation upwards, filling up of acetabulum with new bone. The disease was the result of a scratch from a cat becoming septic. When the boy was first brought to the hospital he had all the symptoms of acute pyæmia—abscesses in various parts, especially one in the right hip. The boy recovered.

Notes.

Prof. ROENTGEN and Sir WILLIAM CROOKES, K.C.B., F.R.S., are at present the only Honorary Members of the Roentgen Society.

Some Uses of X Rays.

M. Radiguet has brought before the French Academy the results of some interesting experiments made by him in the examination of metals, the detection of internal flaws, etc. Blisters could be seen in an aluminium bar one and a half inch thick.

The *Globe* for October 22nd mentions some experiments with potatoes, carried out by MM. Bussard and Condon, at the National Agronomic Laboratories. The density of a potato increases as it is richer in fecula, and consequently allows the rays to pass with more difficulty.

Roentgen Ray Theory.

Although Roentgen Ray literature continues to increase, contributions towards the theory of the subject have not been very numerous during the past quarter. We may mention two papers read before the British Association, one on "Cathode Rays," by Prof. Silvanus Thompson, F.R.S., and another on the "Behaviour of Argon in X Ray Tubes," by Prof. H. L. Callendar, F.R.S., and Mr. N. N. Evans, of McGill University, Montreal.

Two articles also appeared in *Nature*, August 5th, by Messrs. Vosmaer and Ortt, and by Dr. T. C. Porter.

X Ray Tubes.

During September, some correspondence took place in the columns of the *English Mechanic* between J. W., Mr. A. H. Fish, and the Rev. T. E. Espin, on the use of tinfoil, gold paint, or other conducting material round the cathode end of the tubes, as previously described by Mr J Wimshurst. Mr. Espin gives the results of some experiments, showing how the illumination of the tube varied with the position of the tinfoil, and the way in which it was connected.

Radiography.

A contemporary regrets that we still make use of such a barbarous term as "radiography," but does not suggest any other word better calculated to meet the requirements of civilization. The whole truth of the matter is certainly not expressed by the word "radiograph," but perhaps for the present the very vagueness of the term is to some extent a recommendation. Were it that the rays merely cast a silhouette of an object placed between the tube and the plate or screen, then we might say, with Shakespeare, "The best in this kind are but shadows," and be content with "skiagraphy." The Roentgen ray does more than this. The word "pyknography" (πυκνος, dense, obscure) adopted by Drs. Büttner and Müller in their book on "Röntgen'sche Strahlen," comes nearer the mark than skiagraphy. Besides, if the X ray prove to have therapeutic value, it would be difficult to accept skiatherapeutics or the shadow-cure. The Roentgen Society must see to this.

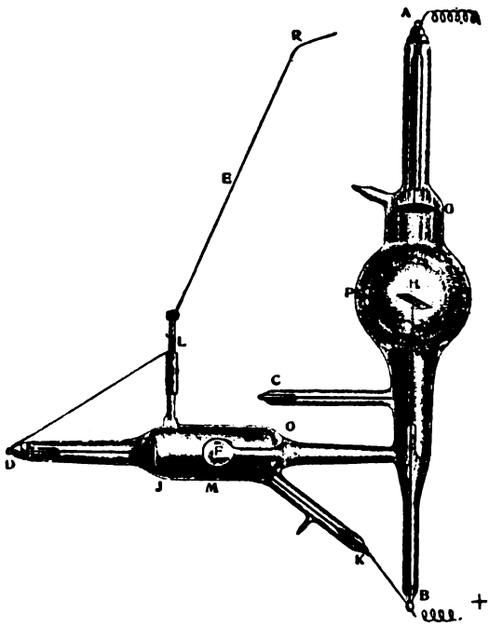
Intensifying Screens.

Some new forms of intensifying screens have recently appeared, which are evidently an improvement on those tried last year. A plate-holder has been constructed, with a screen inside the cover, which acts on the plate and considerably intensifies the effect of the rays. Some special intensifying screens were shown by various instrument makers at the meeting of the Roentgen Society on the 5th instant, which have led to a considerable reduction in the time of exposure, especially when used with special plates and films. Orthochromatic plates appear to be the best for X-ray work both with and

without intensifying screens. Some experiments which throw light on this matter have been described by A. E. Livermore in *Photographic Scraps*, and by J. Gaedick in the *Photographisches Wochenblatt*. Further details of these experiments will be found in the *Electrical Review* of October 15th.

Self-regulating X-Ray Tube.

The essential novelty in this tube consists of the auxiliary arrangement for altering the vacuum. The bulb A contains a chemical which gives off vapour when heated, and re-absorbs it when it cools. The arm B is adjustable, so that the gap G can be varied. The anode of the auxiliary tube is connected to the anode of the main tube. When put in action the resistance of the main tube, being high, causes a current to pass through the auxiliary tube and across the gap G. The discharge from the cathode of the auxiliary tube heats the bulb and drives out the vapour, thus lowering the vacuum. This action continues for a few seconds until a sufficient amount of vapour has been driven into the main tube to permit the current to go through it. After this only an occasional spark will jump across the gap to maintain the tube at a constant vacuum. We are indebted to Messrs. Watson and Sons for the above particulars of this tube.



SELF-REGULATING X RAY TUBE.

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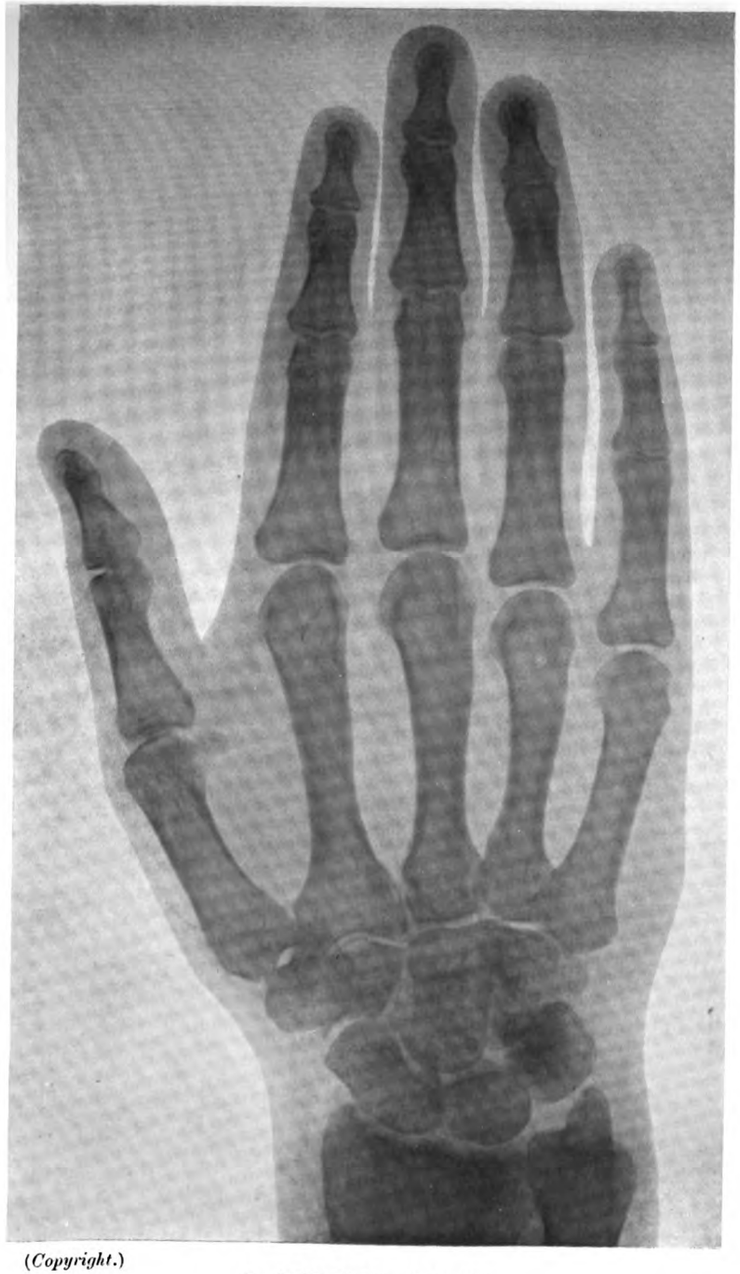

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A NORMAL HAND.

(*By MACKENZIE DAVIDSON, M.B.*)

PLATE XXXI. (*a*)

(*Archives of the Roentgen Ray.*)

(*Copyright.*)

A GOUTY HAND.

(*By WM. WEBSTER, Esq., Blackheath.*)

(5 SECONDS EXPOSURE.)

PLATE XXXI. (*b*)

(*Archives of the Roentgen Ray.*)

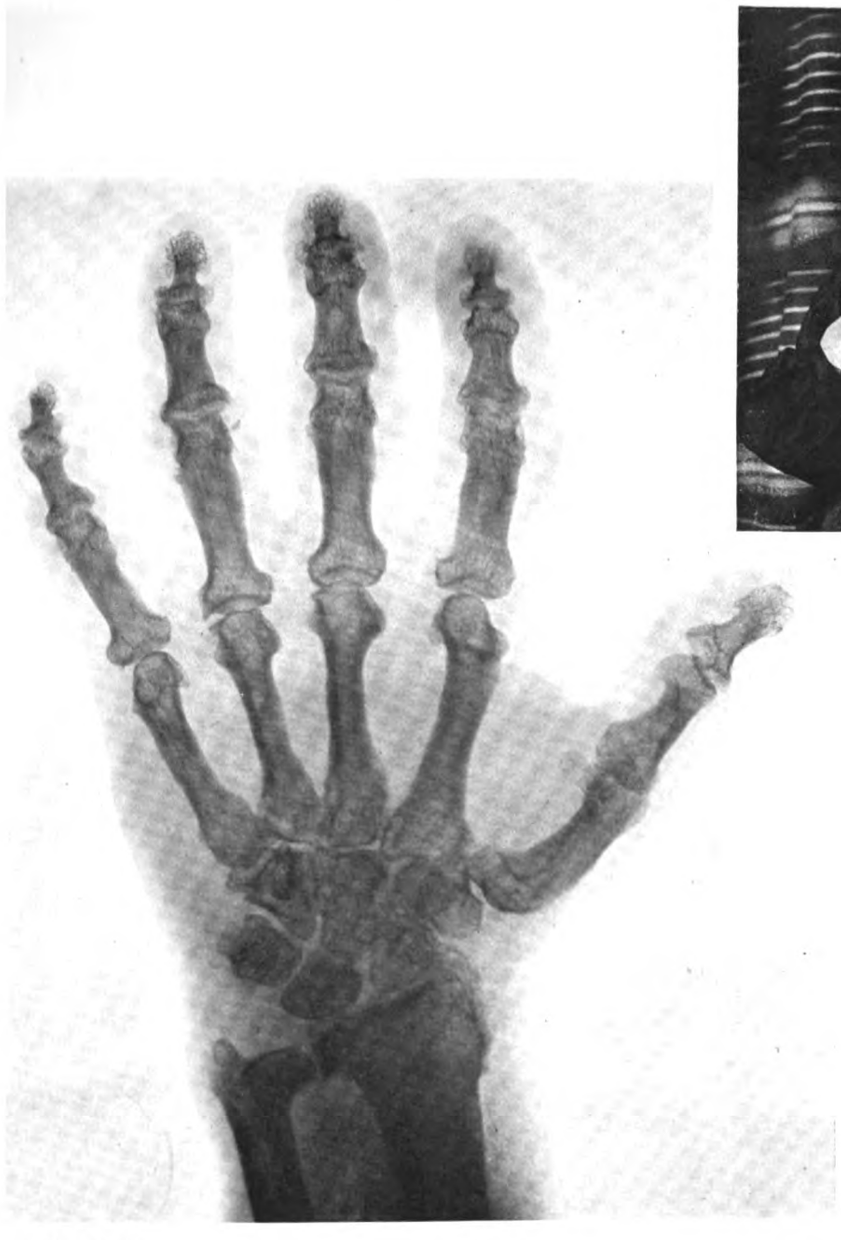
(*Copyright.*)

AN ACROMEGALOUS HAND.

(*By Dr. N. STONE SCOTT, Cleveland, U.S.*)

PLATE XXXII.

(*Archives of the Roentgen Ray.*)



(*Copyright.*)

A CASE OF ACROMEGALY.

(*By ERNEST PAYNE, M.A., Brighton.*)

PLATE XXXIII.

Archives of the Roentgen Ray.)

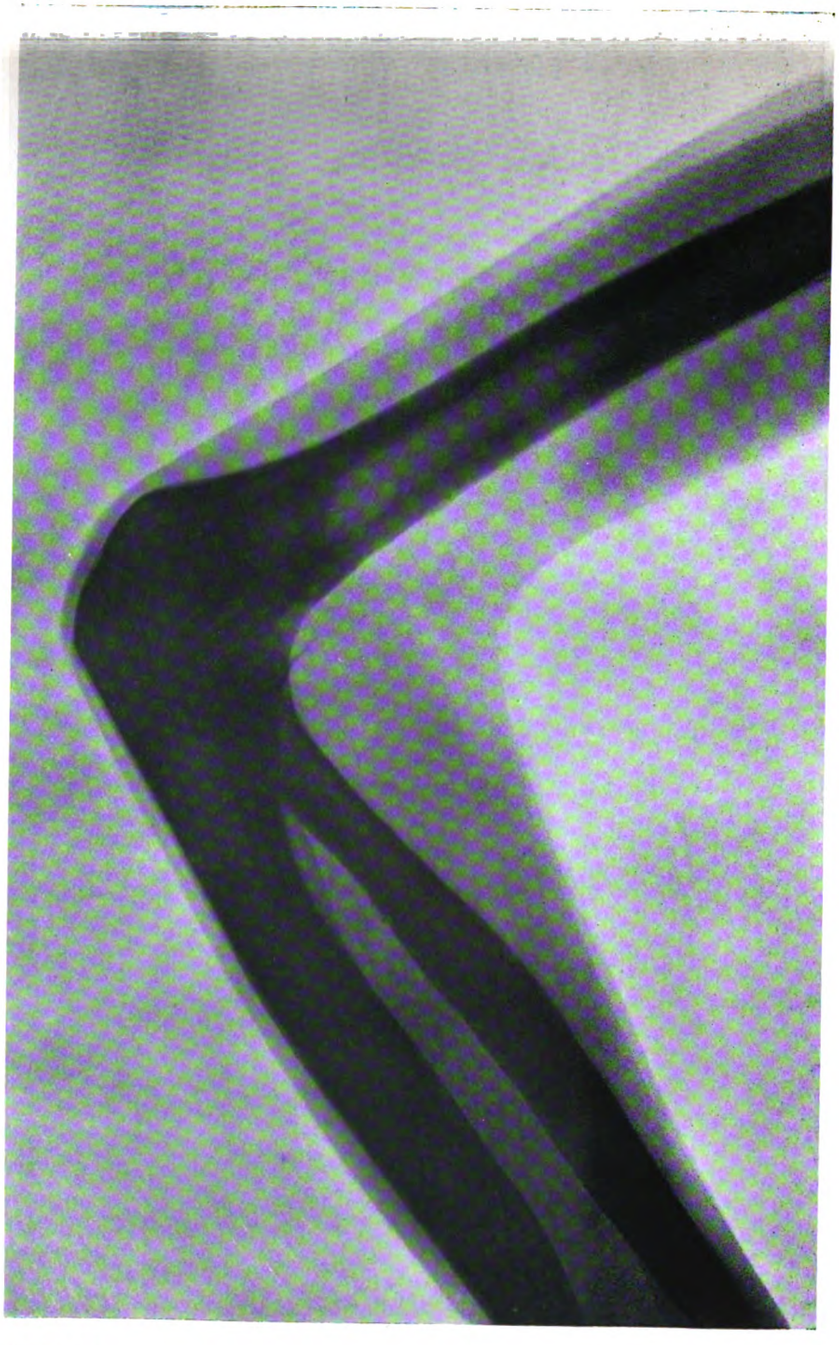
(*Copyright.*)

BONY ANCHYLOSIS OF KNEE.

(*By ERNEST PAYNE, M.A., Brighton. For Dr. A. E. WELLS, Cuckfield.*)

PLATE XXXIV. (*a*)

(*Archives of the Roentgen Ray.*)



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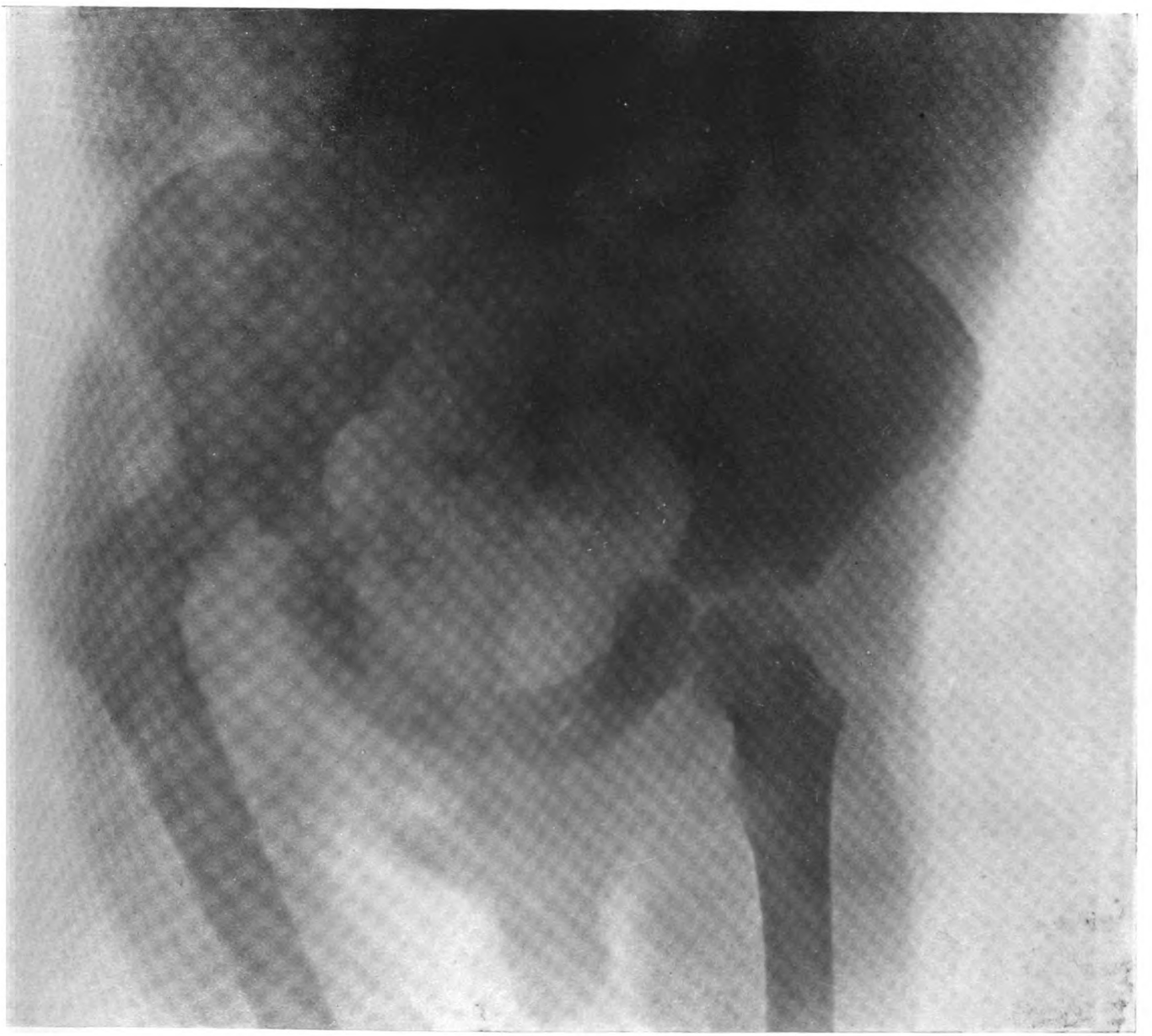
AN ANCHYLOSED ELBOW.

(*By WM. WEBSTER, Esq., Blackheath.*)

PLATE XXXIV. (*b*)



(*Copyright.*)

HIP DISEASE.

(*By ERNEST PAYNE, M.A., Brighton. For Dr. WHITTLE, Brighton.*)

PLATE XXXV.

(*Archives of the Roentgen Ray.*)

Vol. III.—No. 3.] FEBRUARY, 1898. [Price 4/- or $1.

ARCHIVES OF THE ROENTGEN RAY.

EDITORIAL.

The Roentgen Society has fairly entered on its work. The list of its Executive is complete, its meetings are regularly held, new members are steadily coming in, it has an official organ to report its proceedings, and it has found a temporary home in the rooms of the Medical Society, Chandos Street. Since the conversazione on November 5th, two general meetings have been held, both of which addressed themselves to questions of an eminently practical kind.

The work of the Society would appear to lie along three chief lines of inquiry: (1) a study from the purely scientific standpoint of the nature of Roentgen rays; (2) a practical inquiry into the best apparatus for their production; (3) an investigation of all details bearing on their useful application. As an outcome of the latter there must certainly be included the gradual formation of a collection of radiograms for reference and comparison. These should be systematically catalogued, carefully arranged, and easily accessible.

The first of these divisions carries the inquirer into wide fields of scientific research, whose limits it is impossible to define. The second attacks the question from a purely practical and experimental aspect. It concerns itself with methods and apparatus, dealing with such points as vacuum tubes, sources of electrical supply, coils, contact breakers, influence machines, oscillators, and endless other questions of practical electro-physics. Under the third heading the Roentgen ray is considered in its various useful applications. How may it be utilized to the greatest advantage? The sensitive surface upon which it falls, the photographic processes to be employed, the best means of securing definition and detail, the question of radioscopic and intensifying screens, have all to be considered. Under this heading there are also to be studied the best methods of discriminating various structures and alterations therein —whatever the structure be, whether hard or soft, whether the wall of a blood vessel, a solid organ, a muscle, a calculus, a bone, or a gun barrel. And last, but by no means least in importance, comes the measurement of internal parts and the localization of foreign bodies. No aspect of the subject has been more fruitful than that last named of ingenious device and patient work, and now it may be added, of useful results. It has all along been obvious that the true position of a hidden object could best be ascertained by obtaining two shadows, from different points of view, the latter being on the same plane and on the same straight line. Accurate results were early arrived at, sometimes by mathematical calculations, sometimes by geometrical constructions. Early in last year Prof. Marcy, on behalf of MM. Rémy and Contremoulins, made a communication to the Academy of Medicine of Paris, foreshadowing an apparatus which, since then, has been elaborately constructed and successfully used. This "*chercheur de projectiles*" consists of a framework adaptable to the head of the patient, and constructed to carry two focus tubes and a sensitive plate, whilst strings in the subsequent parts of the process represent the path of the X rays. This apparatus has already, in two cases, accomplished the localization (leading to the successful extraction) of a bullet in the living brain. In August, 1897, Drs. Max Levy and Thumim, in a communication to the *Deutsche Medicinsche Wochenschrift*, described a method of making precise measurements by taking one radiograph only, and correcting the errors due to perspective by employing an apparatus which they minutely described. In September, 1897, Mr. Payne sent a contribution to this Journal, describing how, by means of two shadows and the employment of graphic methods without trigonometrical calculations, the exact position of hidden bodies could be ascertained, and exact measurements made. The method of shifting the tube by means of a sliding holder, the marking of the plate by crossing it with fine covered wire moistened with an aniline dye, and the latter in its turn communicating a corresponding mark to the body were all explained. In the *Lancet*,

October, 1897, Drs. Davidson and Hedley described a method, which had occurred to the former, of doing by strings what Payne had done by graphic methods. The device has already, in several instances, proved useful in localizing foreign bodies in the extremities and in the eye, and no doubt when opportunity offers, will equally prove itself of service in the localization of bullets in the brain, and in making measurements of the pelvis. Broadly speaking, it is certain that the surgeon may now trust the radiographer not only to disclose to him the presence of a foreign body, but also its actual position relatively to the surface. A localizing apparatus ought to form part of every radiographer's equipment. The instrument need not be elaborate nor costly. A portable localizer of the highest efficiency, may be obtained for a trifling sum. Localization is one more of the many services rendered to surgery by the Roentgen ray. Radiostereoscopy will be the next.

It is evident that the work of the Roentgen Society, although wide, is not ill-defined. The physicist and the medical man meet here on common ground; they are, in many respects, useful to each other. They claim as their field of work, all that appertains to the Roentgen ray. But they fully recognize the fact that the purely medical aspect of any question must always remain the province of a purely medical society. The dividing line is obvious, and common sense must draw it.

THE ROENTGEN SOCIETY.

An ordinary general meeting of the Roentgen Society was held on Tuesday, December 7th, at the rooms of the Medical Society, Chandos Street. Prof. Gladstone, F.R.S., occupied the chair. There was a good attendance of members and their friends. The Secretary was able to announce a considerable accession of new members. The next meeting was arranged for a date early in January, to be subsequently fixed. Members were reminded that it would add to the interest of the meeting if interesting radiographs were shown or new apparatus exhibited.

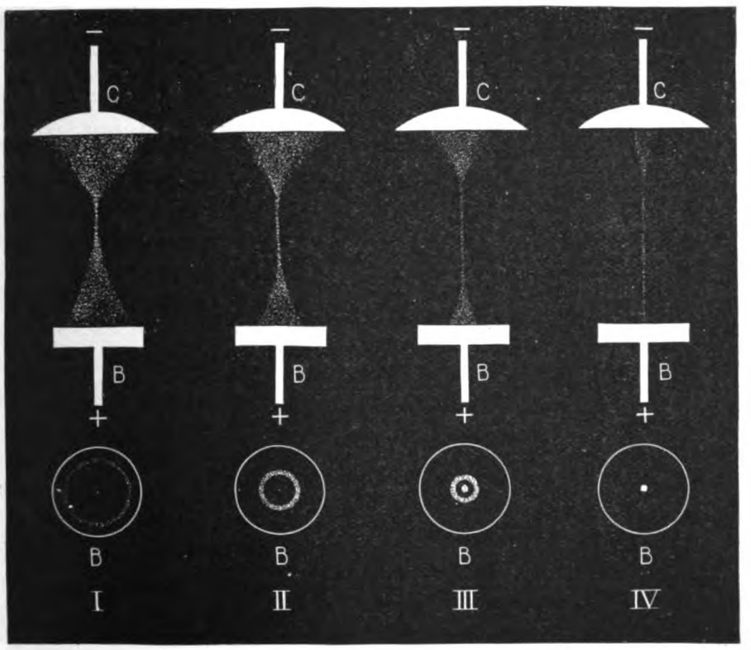
At 8.30, Mr. A. A. Campbell Swinton read a paper on "Adjustable X ray tubes," of which the following is a *verbatim* report:—

The Crookes's radiant matter tube, in some form or other, afforded the only known means by which the Roentgen rays can be generated, and it is, therefore, perhaps, not altogether inappropriate that the first ordinary paper communicated to the Roentgen Society should deal with the design of tubes of this description. As most of those who worked with the various forms of tubes originally employed for producing Roentgen rays will not readily forget, these had many imperfections, and there can be little question that the first real advance after the announcement of Roentgen's discovery, was Mr. Herbert Jackson's adaptation of Crookes's focus tube to X ray purposes. The focus tube gives a quantity of X rays not obtainable with the older forms. It is much less liable to be cracked or injured by the heat of the discharge, while as the X rays all proceed from a very small area, a degree of sharpness is attained in the resulting screen-image, or photograph, that was previously quite unobtainable. The focus tube as originally introduced, though a vast advance on all previous arrangements, is not without its imperfections. Dr. MacIntyre was, I believe, among the first to call attention to the importance of using electric discharges of great electrical quantity in order to produce the best results. These heavy discharges give a much brighter screen, or what is the same thing, they enable photographs to be taken with much shorter exposures. They also cause the X rays to be more penetrative, but at the same time they are very hard upon the tubes. With focus tubes of the original form, heavy discharges will frequently twist up or even melt the platinum, and will usually make it red or white hot. This leads to blackening of the tubes, and to a gradual increase in the resistance, till eventually no discharge can be got to pass.

Recognizing these defects, I set myself some little time ago, in conjunction with Mr. J. C. M. Stanton and Mr. H. Tyson Wolff, the task of investigating the action of the focus tube, with the idea of, if possible, improving the design, so as to admit of heavy discharges being employed, with the view of obtaining easily and continuously the most active and penetrative X rays possible. At the same time, seeing the great variation of the character of the X rays that occurs with very small changes in the degree of exhaustion, and the practical difficulty of obviating such changes in practice, I endeavoured to discover some ready method of adjustment more certain and more easily worked than the auxiliary pumps, potash tubes, and other similar appliances that had at that time been used or suggested for this purpose.

When a focus tube is carefully examined while under the process of exhaustion on the mercury pump, the form of the cathode discharge is found to alter from the initial appearance shown between the cathode C and the anti-

cathode B, in Fig. 1, at a low vacuum, through the appearance shown in Figs. 2 and 3, to that illustrated in Fig. 4, which shows the appearance when the vacuum is high. As will be observed, the cones of cathode rays



in each case converge from the cathode cup to a focus, and then diverge again on the other side of the focus to a less and less extent the higher the vacuum. Finally, at a high degree of exhaustion the cathode discharge does not appear to diverge again perceptibly, at any rate within a moderate distance, but continues in a thin line. It is when this stage of exhaustion is reached that Roentgen rays are given off in their most active and most penetrative form. Experiments show that both the convergent and divergent cones of cathode rays are hollow, and not solid in section. When the concentrated cathode rays are allowed to fall upon a disc of ordinary electric light carbon, the latter exhibits surface luminescence. Except, however, when the disc is exactly at the focus, in which case it shows a bright luminous spot, the intersection of either cone by the disc gives not a solid spot of luminescence, but a hollow luminous ring, which decreases in diameter the higher the exhaustion, as shown in the lower portion of Figs. 1 to 4. It appears further that the cathode rays are not given off from the whole surface of the cathode cup, but only from a ring-shaped portion, the diameter of which is less and less the higher the exhaustion. This, perhaps, explains the reason why very large cathodes give no better results in producing X rays than comparatively small cathodes. Indeed, at the degrees of vacuum necessary to produce penetrative X rays, the greater portion of a very large cathode is apparently ineffective, as the discharge seems to come off entirely from a very small part of the central portion. This is not readily seen with the usual cathode cups of aluminium, but with cups of carbon it is easily observed. Full details of the experiments from which the above facts are derived, will be found in "The Proceedings of the Royal Society," Vol. LXI., pages 79 to 95.

Cathode rays are generally believed in this country to consist of atoms or molecules of residual gas, which, being similarly electrified to the cathode, are repelled by the latter, and travel at an average velocity not much less than one-twentieth that of light. It is obvious, however, that upon such a theory the precise average velocity must depend both upon the exact potential of the cathode and molecules at the moment the latter leave the former, and also upon the degree of exhaustion of the tube, upon which depends the free path of the molecules—that is to say, the distance a molecule can travel before coming in contact with another molecule. Years ago Crookes showed that the deflection of a cathode beam by a magnet depended upon the excitation of the cathode, and upon the degree of exhaustion—that is to say, the deflection was less the higher the velocity of the molecules. More recently Birkeland has produced what he calls "the cathode ray spectrum," from which it appears that the cathode rays are not homogeneous but heterogeneous, some being more easily deflected than others, so that when the cathode stream, passed through a slit, is deflected by a magnetic field, and is then allowed to fall on the glass and cause fluorescence, the result is a series of bands. These bands are in a perpetual state of movement, and the conclusion is obvious that the molecules that form the cathode stream are not all moving at the same rate, but owing to the pulsatory and oscillatory nature of the electric discharge and the varying electrification of the cathode are divided up into groups, which have different velocities, and, being for this reason differently deflected,

strike the glass and cause fluorescence in separately localized bands.

Now, as Prof. S. P. Thompson first pointed out, and as all who have since observed the effects produced on a fluorescent screen while a focus tube is in process of exhaustion, and is at the same time being excited, are aware, there are several different stages as regards the X rays produced. First of all, at less than a certain vacuum there are no X rays; next, as the vacuum increases, X rays show themselves, but of a quality that will do little more than penetrate the backing of the fluorescent screen. As the vacuum is further increased the rays become more penetrative and show the bones in the hand. Next a point is reached, when the flesh of the hand seems to be almost completely transparent, while the bones are almost entirely opaque; at still higher vacua, the bones becoming more and more transparent, the contrast between bones and flesh becoming less and less, till at length, the very highest vacuum at which the discharge will pass, the bones scarcely show at all, owing to their having become almost as transparent as the flesh, and the whole hand throws but a very faint shadow on the screen.

Again, what I have termed the "penetrative value" of the rays is found to be dependent upon the applied E. M. F., that is to say, the difference of potential between the cathode and anode, and the conclusion seems to be irresistible that on the assumption that the cathode rays consist of rapidly moving molecules, which by bombardment of the anticathode cause X rays to originate, that the penetrative value of the X rays depends upon the velocity of these molecules at the moment they strike the anticathode, and to the difference of potential between molecule and anticathode at the moment of impact, or to one or other of these conditions.

I must again refer to Prof. S. P. Thompson's experiments as to the value of different materials for the anticathode, as he was, I believe, the first to discover that the higher the atomic weight of the material the better the result. Further experiment, however, shows that while what I may call the quantity of X rays produced as measured in terms of the brightness of the fluorescent screen, or in inverse terms of the length of exposure necessary to impress to any given degree a photographic plate, is largely dependent on the material of the anticathode being greatest with anticathodes of the highest atomic weight, the penetrative value of the rays—that is to say their power of penetrating opaque substances—is independent of the material of which the anticathode is constructed. For further particulars on this subject I may refer inquirers to "The Proceedings of the Royal Society," Vol. LXI., pages 222 to 226.

To come now to more practical matters, metallic uranium, which is the element with the highest atomic weight (240) is commercially unobtainable at present. It is to hoped that this state of affairs will not continue, as in addition to uranium being probably the most efficient emitter of X rays, it is also stated to have the great further advantage of not blackening the glass, even after prolonged use. Thorium (atomic weight 231) and thallium (203) being also commercially unknown, and bismuth (atomic weight 208), lead (206), mercury (199), and gold (197) being too easibly fusible, platinum with an atomic weight of 194, and a very high fusing point, is the best obtainable material for the anticathode surface.

As platinum is, however, expensive, and thin sheets are apt, if unsupported, to be fused, pierced, or deformed under the bombardment and intense heat, I have found it desirable to mount the platinum disc on a larger and much thicker disc of cheaper metal, which not only supports and prevents mechanical deformation of the platinum, but also acts as a dissipator of heat, in addition to lessening the blackening of the glass, owing to there being only one platinum surface exposed.

In the tube I have now in my hand, which was the first constructed in my laboratory on this plan, the platinum is simply a piece of foil soldered with silver solder upon one side of a penny. Copper or bronze are, however, not good materials to introduce with a high vacuum tube, for as will be observed from this specimen, which has been a good deal used, they are apt, even more than platinum, to cause considerable blackening of the glass, and this blackening tends to increase the resistance of the tube to the electrical discharge.

A much better backing for the platinum is undoubtedly aluminium, but here the difficulty arises that it is very difficult, if not impossible, to solder platinum on to aluminium, and a good contact between the two metals is necessary. A simple plan, and one that has been found very efficacious, is to make the platinum in the form of a disc—say, about 0·4 inch diameter, and about 0·02 inch thick. The aluminium may be one inch diameter and 0·25 inch thick, and upon the face of it there is turned a shallow circular depression, just of sufficient diameter to receive the platinum, but rather deeper than the thick-

ness of the latter. The platinum is tightly wedged into this depression, the edges of which are slightly rivetted over the platinum by hammering.

It has been thought by some that there is an advantage in making the anticathode and the anode of an X ray tube separate, the idea being that in this case there is less blackening. This idea I believe to be erroneous, provided the surface of the electrode which performs both these functions is sufficient to prevent heating, and provided, as is always best, a small spark gap is introduced into the circuit so as to stop out entirely the make current of the induction coil or any reverse oscillation in the discharge which otherwise would during their continuance make the anticathode the cathode for the time being. There can be no doubt, however, both for the permanence of the vacuum and also for the prevention of blackening, of the importance of preventing the overheating of the anticathode, and, though the mass of aluminium I use and recommend is very efficacious in this direction, I am of opinion that as more and more electrical power is employed in order to obtain better and better results some other arrangement for taking away the heat—say, in the direction of water or mercury circulation through the anticathode — will be found advantageous.

As already mentioned, one of the results of a red or white hot anticathode is a rapid deposition of platinum and blackening on the glass. This finely-divided coating of platinum occludes the residual gas and causes the vacuum to become too high. Heating the glass will to some extent restore matters to their proper condition temporarily, but, apart from the degree of vacuum, the blackening seems also to have an effect in increasing the resistance of the tube, which is very probably analogous to what Crookes discovered when he found that a non-fluorescent coating on the inside of a tube increased the resistance of that tube to the passage of the electric discharge.

The precise distance between the cathode and the anticathode is not of great importance, provided the degree of exhaustion is suitable, and provided that the anticathode is beyond the focal point at which the convergent cathode rays meet together at low exhaustions. It is well, however, not to fix the anticathode too far beyond the focus, as this necessitates a higher exhaustion in order to obtain penetrative X rays, and as too great a distance also impairs the sharpness of the resulting image.

The distance between cathode and anticathode has, however, a considerable effect upon the resistance of the tube, and upon the character of the X rays it generates. In fact, adjustable tubes with which X rays of any desired penetrative power can be obtained at will without altering the degree of exhaustion, or in which the unavoidable variations of vacuum which are found to take place in practice, can easily be compensated for, can be arranged with a moveable anticathode mounted on a sliding rod, so that the distance between cathode and anticathode can be varied by gently tapping the tube.

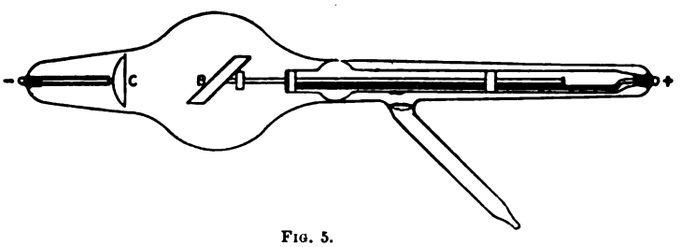


FIG. 5.

In air at ordinary atmospheric pressure, the nearer the discharge points are together the more easily the spark takes place between them; that is to say, the shorter the distance the spark has to leap, the less is the difference of potential required to make it leap. Curiously enough in high vacua the exact contrary is the case, and the discharge passes with much greater difficulty over a short gap than over a long one. This may be readily with an adjustable tube such as that I will now show (Fig. 5), and in which I can alter the distance between cathode and anticathode. By moving the latter, as will be seen when the distance is very small inside the tube, say only one quarter of an inch, the spark prefers the alternative gap outside of about four inches, while if the internal gap is increased about three inches, the discharge then prefers this path, and the exterior gap must now be shortened to about half an inch before the spark will travel that way. It is further found that, in a tube of this description, exhausted to a constant vacuum, the nearer the anticathode is moved up to the cathode and the higher the consequent resistance, the more penetrative are the X rays; while moving the anticathode in the opposite direction, and thus making the distance greater and the resistance less, makes the X rays less penetrative. This form of tube was the first adjustable tube designed and made in my laboratory, but this has now been superseded by others which have a greater range of adjustment, and are consequently to be preferred. One disadvantage that it possesses, is that the point of origin of the X rays is moved for each adjustment. It has also

the defect that, if the distance between cathode and anticathode is made very great, so as to obtain much range, there is a tendency to a want of sharpness, owing to the X rays being given off, not from a point, but from a considerable area. This, which has been observed in experiment, seems to show that, contrary to what has been stated by others, the cathode rays always do diverge again to some extent after passing the focus though they do so at a greater and greater distance beyond the focus the higher is the exhaustion.

I have here an adjustable tube made by Messrs. John J. Griffin & Sons, which depends for its action upon the principle that I have just enunciated, namely, that the greater the distance between cathode and anticathode, the less penetrative, and the less the distance the more penetrative are the rays. In this tube, however, the anticathode is fixed, and it is the cathode that is moveable, while the adjustment of the cathode is affected by magnetic means, according to an ingenious suggestion of Dr. Dawson Turner.

The size of the cathode cup itself is also found to have a very great effect upon the penetrative value of

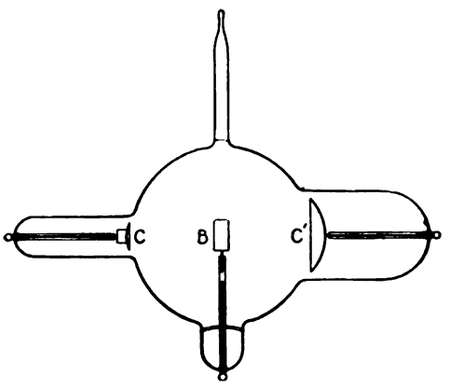


Fig. 6.

the X rays produced in any given vacuum. I have here a tube (Fig. 6) which is furnished with two cathodes, both of the same curvature (0·75 inch radius), but one of much greater area than the other, the larger being 1·125 inch, and the smaller 0·375 inch diameter. Both cathodes focus upon opposite sides of the same anticathode, which is placed midway between them. All are in the same tube, and consequently in the same vacuum. If I connect the larger cathode, leaving the smaller one for the moment idle, you will see that the X rays produced are of a very poor penetrative quality, the result giving the appearance of too low an exhaustion. I now disconnect the larger cathode, and connect the small one. I now have an abundance of highly penetrative rays. I may further point out that the resistance of the tube as measured by the length of the alternative spark in air, is much less when the large cathode is in operation than when using the small cathode. Further, if this tube is more highly exhausted, so as to give rays of good penetration with the large cathode, the resistance with the small cathode is so high that the discharge will hardly pass at all.

I have here another tube shown in elevation and plan in

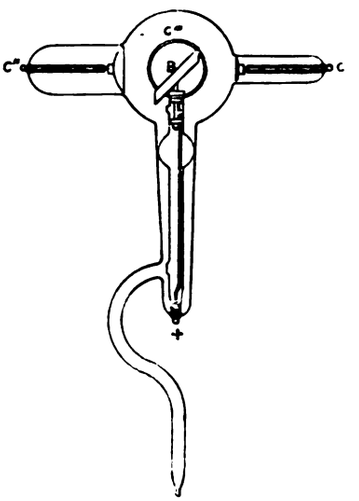


Fig. 7.—Elevation.

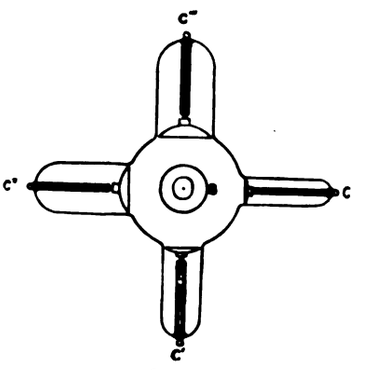


Fig. 8.—Plan.

Figs. 7 and 8, fitted with four cathodes of 0·5 inch, 0·75 inch, 1 inch, and 1·125 inch diameter respectively. They all have the same radius of curvature, *i.e.*, 0·75 inch, and all focus upon the same point on the anticathode, which is mounted

upon a spindle, so that it can be turned round so as to face any one of them. With this tube, as with the last shown, it is found that the larger the cathode the less penetrative, and the smaller the cathode the more penetrative are the rays produced. There appears to be no advantage in employing extra large cathodes, even when the exhaustion is made to suit them. Experiments with various sizes, from 2·5 inches diameter down to 0·125 inch diameter, go to show that even with the full power of a 10-inch induction coil with mercury break, there is no advantage in making the cathodes more than 1·125 inch diameter. For use with a 10-inch coil they should not be smaller than about 0·375 inch diameter, as, if less than this, they are apt to become overheated, and their surface and form destroyed. For use with 6-inch and smaller coils, very small cathodes, even down to 0·125 inch diameter, will work very well, and will not require such high exhaustion as larger ones. Small cathodes should, in proportion, have a less focal length than large ones for the best results. Probably, a good average size for ordinary work is about 1·125 inch diameter, and 0·75 inch radius of curvature. It is important for the best work that the surface should be well polished, and to be of quite even curvature.

Another simple and, in my opinion, altogether superior form of adjustable tube, which has the advantage of a

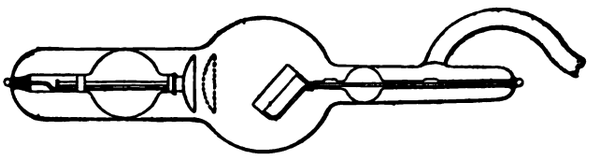


Fig. 9.

fixed point of origin for the X rays, and which has a great range of adjustment, depends for its action upon the fact that the resistance of the tube and the penetrative value of the X rays that it generates can be greatly varied by altering the radius of the annular space between the edge of the cathode and the glass of the containing bulb. In this tube (Fig. 9) the anticathede is fixed, but the cathode is mounted upon a steel rod, held in guides, so that by gently tapping the tube the cathode can be moved to a small extent—say, about one-half of an inch—in and out of an annex, blown on one side of the glass bulb. The shape of the walls of this annex are such that when the cathode is at one end of its travel, and as far as it can get from the anticathode, the edge of the cathode is very near the glass all round; while as the cathode is moved nearer to the anticathode the annular space between the cathode edge and the glass becomes larger and larger, until at the other end of the travel the cathode emerges from the annex into the bulb itself. With a tube of this construction the greater or less proximity of the glass to the cathode is found to have a much larger effect in increasing or decreasing the resistance of the tube and the penetrative value of the X rays than the contrary result that would be occasioned by the alteration in the distance between cathode and anticathode. A travel of one-half of an inch is sufficient to alter the X rays from the highest to the lowest penetrative value, and between the limits of travel any desired degree of penetrative value is immediately obtained. The adjustable tube just shown was made in my laboratory, but here are two others on the same principle, made respectively by Messrs. W. Watson & Sons and Mr. Cossor, who have kindly lent them to me for exhibition.

In conclusion, I should like to lay stress upon the great importance of good and accurate workmanship in the making of X ray tubes if the best results are to be obtained. In no instrument is workmanship of the cheap and nasty description more to be deprecated. Bulbs should be of uniform thickness, and as thin as will bear the atmospheric pressure. Cathode and anticathode should be placed axially so as to produce accurate focussing, and so that they are symmetrical with the glass. The platinum leading-in wires should not be too small, or by becoming overheated they may crack the glass. The cathode and anticathode should be substantially supported so that they cannot become displaced. The cathode should not merely be roughly stamped out of sheet metal, but should be turned up and polished on a lathe to a true spherical surface. The terminals should be substantial and a long distance apart so as to preclude sparking between them.

As the application of considerable electrical power is found in practice to give the best results, the anticathode should be of sufficient mass not to readily become overheated or deformed. The exhaustion should be most carefully carried out, till as far as possible a permanent degree of vacuum is obtained. Even if tubes made in this way cost more than others, they will give much superior results. They will also prove much more durable, and will in many cases stand being re-exhausted many times. Finally, if eventually the glass is cracked or broken, or becomes too much blackened, the cathode and anticathode will serve again to make another tube.

I trust that I have not wearied you with too much

detail, but it is upon detail chiefly that success depends—at any rate, so far as X ray tubes are concerned—and, after all, of all the apparatus that the practical user of the Roentgen rays employs, the tube is the most important, and perhaps I may say also, the least generally understood.

I must mention, in conclusion, how much I am indebted to the untiring assistance of Mr. J. C. M. Stanton and Mr. H. Tyson Wolff, who have made and exhausted all my experimental tubes, and without whose willing aid I do not suppose I should ever have attacked these very difficult problems.

The CHAIRMAN remarked that the subject of the paper was appropriate, because that Society was founded upon the Crookes's tube. It was right that they should begin with the scientific basis. Later they might expect communications arising from the original discovery, and dealing with the investigation of animal and vegetable bodies generally. The chance observation of Roentgen had specially opened up many fields of medical work.

Mr. O'GORMAN asked if Mr. Swinton, who we know was following — or rather leading—in the Marconi investigations, had inquired into any relationship that might exist between the intensity of Hertz waves, as detected by the coherer and the penetrating power of the X rays.

Mr. HIBBERD observed that there was a great range in the penetrative power of the tubes, and workers often wanted a particular type of X rays. Mr. Swinton had demonstrated by screen that the best way of recognizing the quality of the rays.

Mr. WILSON NOBLE was anxious to know how tubes could be adjusted for photographic or screen work, as it did not seem to follow that a tube good for one purpose was necessarily or as a fact good for the other.

Mr. ROLLO APPLEYARD asked whether by "resistance" Mr. Swinton referred to electrical resistance as generally understood, or to spark-resisting power. He said he had recently experimented upon coherence of gases with Hertz oscillators. No result could be obtained as between soap bubbles filled with coal gas. Nor was there any cohesion between liquids in the spheroidal state, nor could he observe any change in the form of smoke rings under Hertz oscillations. Mr. Appleyard thought that the question of "quantity" could be studied by comparing the results obtained, say with a Wimshurst machine and an induction coil. Also by connecting a condenser between the electrodes of the X ray tube.

Mr. PAYNE asked if Mr. Swinton had tried any experiments with the third terminal—an anode; also whether the position of the anode affected the working of the tube, especially with regard to distance from the glass.

In reply to Mr. O'Gorman, Mr. Swinton stated that he had endeavoured some time ago to ascertain whether the passage of X rays through the particles of a carbon coherer affected the resistance of the latter, but was met with the difficulty that the Hertzian waves set up by the electric discharge were so powerful that it was impossible to discover whether the strong effects produced on the coherer were due to the electrical discharges *per se*, or were also in any way due to the presence of X rays. Mr. Swinton further pointed out that a very interesting question was involved, and suggested that the generation of X rays might be exactly similar in method to the generation of Hertzian rays, the X rays being caused by electrical oscillations in the single molecules or atoms composing the cathode rays at the moment of these giving up their charges to the anticathode, in a precisely similar way as Hertzian waves are generated by electrical oscillations in the large metallic balls of a Righi oscillator. In reply to Mr. Hibberd, the lecturer stated that though he had employed a screen as a ready means of showing the differences in penetrative value of the X rays produced under different conditions, of course a much more accurate method was to test the result by actual photographic action. He quite agreed with Mr. Wilson Noble that the best character of rays for photographic action were not the best for screen work. With the adjustable tube, however, any desired character of ray could be readily obtained, and the most suitable kind of ray for any particular purpose could be found by experiment. In reply to Mr. Rollo Appleyard, he said that when he referred to the resistance of the tube, he meant the resistance as measured by the length of the alternative spark in air.

In reply to Mr. Payne, Mr. Swinton pointed out that practically the whole interior of an X-ray tube, except the portion in the immediate vicinity of the cathode, was in an anodic condition. The anode could, therefore, be looked upon merely as a connection from the exterior of the glass to the inside conducting gas. Consequently, within limits, the position of the anode did not to any great extent affect the result, nor did it much signify whether anode and anticathode were in metallic connection. If, however, a moveable anode was employed which could be brought very near to the cathode, this effected the result, and experiment seems to show that an adjustable tube could

probably be made on these lines. Mr. Swinton had experimented in this direction, but had not obtained very satisfactory results.

CONTACT-BREAKERS.

By ERNEST PAYNE, M.A., A.I.E.E.

I.

THE employment of the induction coil in connection with Roentgen rays has led to the revival of many forms of contact-breakers used by early experimenters with the "inductorium,' and to the design of several new forms with the object of increasing the efficiency of the induction coil when used for working X ray tubes. It is not the writer's object to give a history of the various forms of "breaker" that have been designed by past and present workers, which would fill a volume of considerable size, but merely to notice briefly the classes into which the different contact-breakers may be divided, and then to proceed to the description of a few forms of the apparatus with which he has had some practical experience. The good working of a contact-breaker does not depend only upon its design and construction, but also to some extent upon the skill and experience of the experimenter in being able to adjust the working parts so as to give the best effects with the coil and tube which he is using. Many of the early forms were designed to produce the largest number of "makes" and "breaks" per minute, but when used for producing Roentgen rays it would seem that the completeness of the make and suddenness of the break are points which must receive considerable attention, even at the expense of rapidity of action.

Contact-breakers may be divided into two general classes, those in which the driving force is derived from the action of the main current passing through the "primary" of the induction coil, and those in which some independent driving power is employed—such as an electric motor or clock-work.

Again, considered with regard to the exact form of "make and break" employed, they will fall into three divisions:—First, those in which the "make-and-break" takes place between two pieces of metal that are first brought into contact with one another and then separated; the familiar form of hammer break is the best example of this class. Secondly, there are those in which there is a rubbing or sliding contact between two metal surfaces, the continuity being broken by the introduction of suitable pieces of insulating material; the rotary break, resembling in outward appearance the commutator of a dynamo, is the usual form of this kind. Thirdly, there are those in which a liquid (mercury) break is used, with a contact rod dipping into a cup containing mercury.

Contact-breakers that are worked by the current passing through the primary circuit vary in speed—within certain limits in each case—as the current itself is varied, by the alteration of the resistance of the circuit or of the electro-motive force employed. Special devices can of course be employed to prevent this, to some extent, as in the form described and illustrated below in Fig. 1 by raising or lowering the sliding weight W. "Breakers" that have an independent drive can be kept at a constant speed for all values of the current in the primary. It seems impossible at present to assert that any one form is superior to all others. For general convenience and simplicity those of the first class seem preferable; where a large number of breaks per minute is required, those of the second class seem best; for complete make, and sudden, complete break, those of the third kind have many good points to recommend them.

Fig. 1 shows a special form of "Vril" break made for me by Messrs. Watson & Sons. In principle it is

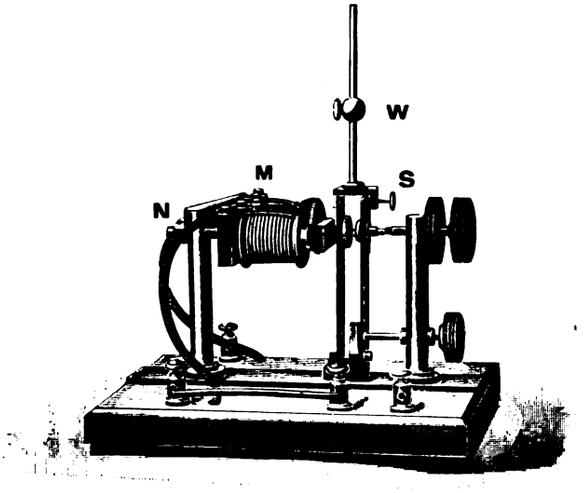


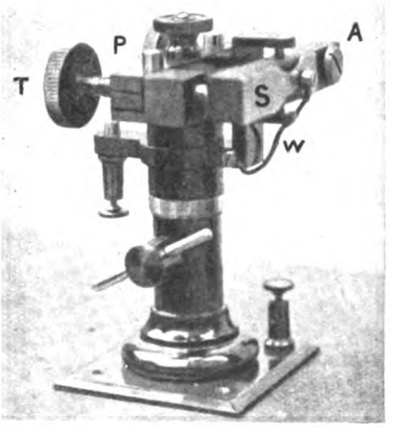
FIG. 1.

similar to the usual form of "Vril" break supplied with their coils, but with a separate electro-magnet added for driving, so that it may be placed in circuit with any coil where the armature could not be conveniently worked by the coil of the primary current. The main current passes round the electro-magnet M, and thence across the break

in the usual way. The magnet is mounted on a separate pillar and at the extremity of a screwed rod, held in place with a lock nut N, so that it can be turned round into the horizontal (as in the illustration) or into the vertical position and adjusted at any suitable distance from the armature, which can also be turned in either position to face the magnet. In these breaks it may be noticed that the armature is mounted on a second spring, independent of that carrying the platinum contact, so that the latter remains in connection with the fixed contact until the armature swings back towards the magnet, pulling the contacts apart. The duration of the contact can be altered by means of the small screw S.

The breaker shown in Fig. 2 is a modified Deprez break made by Messrs. Ernecke, of Berlin. The armature consists of a heavy bar A, moving horizontally and set between two centres, whose axis is vertical, passing through

Fig 2.



the middle of the bar. One of the adjustable screws P carries the fixed platinum contact; the other screw T passes through a hole in the bar and presses against a spring S attached to the former—"for regulating" the length of break, the screw being provided with an insulating end-piece to prevent metallic contact. The current enters at the terminal on the base and passes by the fixed contact to the one on the armature; thence by the flexible wire connection W to the other terminal seen fixed upside down to the small projecting bracket. This breaker works very rapidly and gives excellent results with steady light for working with fluorescent screens.

Next may be noticed a special form of mercury break, of which a sketch elevation is shown in Fig. 3. It has a double "make-and-break" and independent driving mechanism.

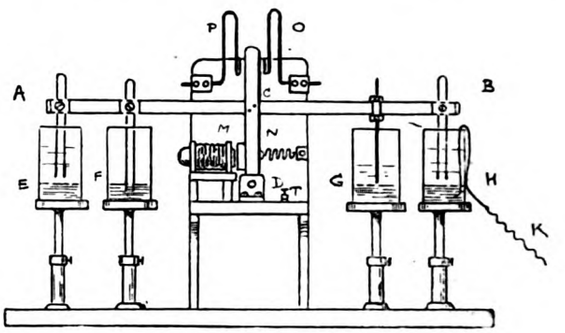


Fig. 3.

It was designed by myself originally to work a coil on the condenser discharge method. The central contact went to the condenser, while the coil was attached to the mercury cup at one end of the arm, and the battery to the cup at the other end. Finding that the condensers at my disposal (about eight microfarads) were not nearly large enough for the purpose, the experiments were abandoned after one or two trials, and the contact breaker was adapted to working the coil with the direct current from the battery. The induction coil has been worked successfully with X-ray tubes on the condenser discharge method by Messrs. Norton and Lawrence, who described their method in a letter published in *Nature*, vol. 55, page 461. They employed a specially wound primary on the coil, and condenser of a total capacity of twenty-seven microfarads.

Referring to Fig. 3, A B is a rigid horizontal bar fixed to a vertical portion at C, and moving on a centre pin D, after the manner of an ordinary balance. This bar carries four contact rods, dipping into four mercury cups; the cups E, F and H belong to the main circuit, while G forms the "make and break" for the driving circuit. The driving current enters at the terminal T, passes thence to the electro-magnet M, and by a flexible wire to the moving arm, then down the contact-rod to the cup G, whence it returns to the battery. To avoid confusion, only one of the connecting wires for the mercury cups is shown at H. This form of contact is not necessary if the cup has a metal bottom; the current will then pass down the support and away to the battery by a suitable wire connection. The main current for the induction coil enters at the cup F, where the dipping-rod makes permanent contact. A flexible contact may also be used for this, as for the driving circuit,

if arranged so as to allow free movement to the oscillating arm. When the end A is down the current passes along to the cup E, and out to the primary of the coil. When B is down it passes by the cup H, the height of the mercury being adjusted in E and H, so that both cups are never in contact at the same time. When contact is completely broken at E it is made at H, and *vice versâ*. There are thus two makes and two breaks for every complete oscillation of the arm A B. By arranging the centre of movement at D, the latter is in a line with the mercury in E and H, the movements of the dipping-rods are as far as possible vertical, and cause the least disturbance of the mercury.

The rate of movement depends on the current supplied to the driving circuit and on the duration of contact in the cup G. The springs B and O play an important part in the smooth working of the apparatus. These may be of any suitable form, either spiral or C-shaped; they are adjusted according to the amount of movement and length of break required. The driving circuit is closed first, so that the arm may be in motion before switching on the main current. This avoids a short circuit with the cup that is in contact. By raising or lowering the cups the length of break can be altered while the arm is in motion.

Two or three dry cells are sufficient for the driving circuit when the arrangement shown in the figure is used. An electric motor may be employed for driving instead of the magnet and mercury break, by attaching a crank rod to the spindle of the motor and to a suitable point on the arm A B. There is another method of working this "break," by omitting the cup F and raising the cups E and H, so that both are in contact for an instant, the connections being made so that the current enters at one of them and leaves at the other. Two "makes and breaks" are then obtained for each complete oscillation as before.

The writer has been able to work tubes with this double mercury break when the vacuum of the former had become too high to run well with a hammer break.

It is advisable to screw the apparatus down to the table, as the movement of the oscillating arm is apt to shake the mercury cups, and interfere with the smoothness of the make and break.

It is to be hoped that future articles will follow, by other workers, when each author will give the results of work done with other forms of contact-breakers. It would be interesting to have more detailed accounts of the condenser-discharge method, so successfully worked out by Messrs. Norton and Lawrence, of the double hammer break employed by Dr. Macintyre, and also of the rotary contact-breaker.

A CASE OF COXA VARA.

With Remarks on the Radiography of the Hip Joint.

By Wm. IRVINE FORTESCUE, M.B., C.M., Aberdeen.

D. Y., aged fifteen, was admitted to the Royal Infirmary, Aberdeen, on 30th April, 1896. He presented the usual symptoms, and typical physical signs of coxa vara, as described in the April number of the *Practitioner* for

FIG. 1.—Coxa Vara. (Retouched Print.)

last year by Prof. Ogston, under whose care he remained for eight weeks. Mr. McKenzie Davidson skiagraphed the right hip of the patient, who was laid face downwards.

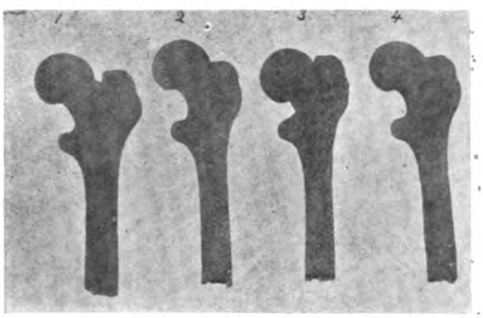


FIG. 2.—Silhouettes of Head of Femur.

The Crookes's tube was fixed directly over the neck of the femur, and at a distance of eighteen inches from the sensitive plate, which was enveloped in two folds of black cloth, and placed beneath the pelvis. The exposure was, I believe, about half-an-hour. The negative turned out

rather thin, and the print has been retouched, but the original outline has been carefully preserved.

When photographing some of the skiagrams of cases of coxa vara in Prof. Ogston's possession, I was led to

Fig. 3.—Silhouettes of Head of Femur.

make drawings of the shadows thrown by the necks of femurs. In all the silhouettes reproduced the same femur —a normal adult bone—was used. Its shaft was fixed as parallel as possible to the paper, and at a distance of four inches from it. The light was placed eighteen inches from

Fig. 4.—Photograph of Pelvis, toes pointing straight forwards. Lens perpendicular to junction of Sacrum and Coccyx.

the paper. The various changes in form were caused by altering the position of the lamp, and by rotating the bone outwards, but in every case the relative positions were such as might occur in skiagraphing a hip joint. Space will not admit of a detailed description of these.

It is self-evident that in order to obtain the best possible radiograph of the neck of a femur it must be placed parallel to the sensitive film, and the tube must be perpendicular to both the centre of the neck, and to the film, as in No. 5. It is easiest to attain these conditions —especially in cases of hip joint disease, where there is usually eversion—by placing the patient prone. It is hardly possible to obtain a useful skiagram of the necks of both femurs at the same time if the patient be laid supine, and if the Crookes's tube be within eighteen inches of the film, and over the symphysis pubes, because in this position the necks are so foreshortened that the shadow of the head blends, or almost blends, with that of the great trochanter. It will be noted that the shadow of the lesser trochanter is proportionately much magnified. If a line be drawn at right angles to the axis of the shaft of a femur, and just touching the upper surface of the head, it will pass above the great trochanter in a normal bone, but will touch or intersect the trochanter when there is rickety curvature of the neck. Great care, however, is necessary in arranging the patient and in placing the tube to avoid erroneous results.

THE ROENTGEN SOCIETY.

An Ordinary General Meeting of the Roentgen Society was held on January 11th, 1898, at 11, Chandos Street, Cavendish Square, W.; the President, Prof. Silvanus Thompson, in the chair. The minutes of the previous meeting were read and confirmed.

The following candidates were then balloted for, and elected members:—J. S. Bullock, M.D.; Dr. Ludwig Mond; J. Pender Smith, M.D. (Dingwall, N.B.); Max Byng; W. G. Barnes, jun.; Edmund Frost (Eastbourne); H. Newby; J. H. Morgan, F.R.C.S.; C. N. Peal, F.L.S.; Ernest Harnack.

The following candidates were recommended for ballot at the next general meeting, which was announced for the 1st February, 1898, 8 p.m., at 11, Chandos Street, Cavendish Square:—Dr. Penrose Williams (Dunster); F. Watson Baker; Francis Trice; Watkin Williams; E. H. Howlett, F.R.C.S. (Hull); G. M. Lowe, M.D. (Lincoln); James Wimshurst.

The President announced that the agreement had been concluded with the Rebman Publishing Company, whereby each member would receive quarterly a copy of

the ARCHIVES OF THE ROENTGEN RAY, containing the official proceedings of the Society.

A paper was then read by Mr. WILLIAM WEBSTER, F.C.S., on "Practical X Ray Work":—

It is somewhat difficult in a paper of this description to avoid appearing to dictate to other workers—a position which I do not assume—but, having since January, 1896, used, almost exclusively, one type of apparatus with satisfactory results, I have now settled down to a particular mode of procedure, which I shall demonstrate this evening.

In my early work with vacuum tubes, dating from 1872, when they were merely used as toys for lecture purposes, and in which year I became possessor of a collection of an improved type of Geissler tubes, I used primary batteries of the Grove's type, with a 6-inch coil (made in England); and from January, 1896, to August of that year I used a similar type of battery with the same coil. But primary batteries are by no means satisfactory for continuous work in this branch of science, unless half-gallon or gallon cells are used with nitrate of soda and sulphuric acid, instead of nitric acid in porous cell, in which case, when the battery is in action, nitric acid is produced as required, the E.M.F. is practically constant, and one charge of chemicals will last as long as fourteen days without any considerable osmatic action. This type is known as the "Holmes-Burke," and is, undoubtedly, the best primary battery ever put together, the only drawback being the zincs, which require careful mercurizing at the end of each run of fourteen days. With nitric acid the zincs require mercurizing every twenty-four hours. But primary batteries cannot be used for portable purposes, and give off nitric oxide fumes. This can be palliated by mixing chromic acid with the liquor in the porous or positive cell, but this again in process of time leads to disintegration of the carbons. The cost of platinum foil* is prohibitive, but it can be used in place of carbons with the chromic solution without local action.

Bichromate single or double fluid batteries are of no use, as polarization is sure to take place with a discharge necessary for working a coil.

The secondary battery, of the type I have here, is altogether the best for practical use.

The ampère capacity of a battery of this type is about twenty-five hours: actual working, about eighteen hours; it is not safe to use more than two-thirds of the total charge; practically it is a primary single fluid battery, for the so-called charging is nothing more than chemical action produced on the plates by electrolysis; the positive plate becoming peroxidized, and the negative plate deoxidized. When a current is taken from a cell the negative plate gradually oxidizes and the positive plate deoxidizes. When both plates reach the same degree of oxidization the cell needs re-charging, but in practice it is never safe to run to this point, as you risk sulphating. Overcharging the battery does no harm, provided a current of not more than four amperès per square foot of plate is used, and in the case of portable batteries of the type and size I have here this evening, a current of not more than three ampères should be used to charge, therefore it takes about eight hours to completely charge.

In discharging, a current of not more than four ampères for an hour or two's run is on the safe side when the plates are in good order, otherwise polarization will take place, and the worker inexperienced in secondary batteries will blame the "make and break" of coil, or imagine the battery is insufficiently charged. A resistance should be used for safety. The best portable battery in my possession was obtained from Messrs. Johnson & Phillips, but the lithanode batteries I have here are quite good enough provided they are kept well fed with current and do not leak. A ¼-H.P. gas engine and ⅕-H.P. dynamo are quite enough to keep this battery in working order, as from many months' experience I have proved. These batteries have been in work eighteen months—a fair test.

Coils I need not enlarge upon, as there are many good ones in the market, the best being undoubtedly of English make. The 20-inch coil in front of me was supplied to me by Messrs. Newton, and is known as a Newton-Apps; it is entirely of English manufacture, gives a constant 20-inch spark, if required, and with a pneumatic buffer to assist in regulating the "make and break," seems to be all that can be desired. You will notice during the working with the tube that the sparking between "make and break" is infinitesimal.

Any worker inexperienced in coils will probably spoil a coil even of this type in a very few minutes by allowing the platinums to "jam." Working with small accumulators, one should be careful to keep adjusting the "make and break" of coil, as the discharge from batteries is by no means homogeneous, and if the worker wishes to obtain

* Platinum foil becomes brittle, and requires heating to bright red in muffles, so as to regain its pliable qualities.

* A type of 100 ampère power or more is best for laboratory work, so as to avoid repeated charging at short intervals.

that desirable condition of tube showing an electrical molecular photosphere in a state of gentle wave oscillation, or at rest, this is important.

To Sir William Crookes we undoubtedly owe the fact that the X rays were ever noticed, for if he had not invented his tube this Society would not have been in existence. He informed me that during an experiment with a camera and one of his tubes he noticed, on developing the plates, that certain marks corresponding to his fingers appeared on the films, and thinking it was due to defective plates, returned them to the makers with some strong remarks. Now, if he had only thought of the tube, Crookes would have been first in the field, for the experiment took place before Roentgen's discovery.

Prof. Jackson made his first focus tube in 1894, and here it is. You will observe that it is exactly the same form which is now used throughout the scientific world, and it was during that year that he was actually experimenting with phosphorescing small screens, made with potassium-platino-cyanide, when he demonstrated the fact that wood, vulcanite, and allied materials were pervious to certain rays produced by the electrical bombardment in this very tube; and also that metals were impervious to certain rays, but pervious in varying degrees to others. I have not only this evidence from Prof. Jackson's own mouth, but also from others who knew of his experimental work. Surely *this* was *the* discovery? for Prof. Roentgen observed somewhat accidentally the bones in his fingers, and put the finishing touch to the work of the two Englishmen.

All honour to him for it! But I venture to say that the Union Jack can be placed almost entirely over the discovery.

The Jackson tubes I have with me are of exactly the same form as the original one, but the one I have in my hand is modified by having a glass tube at the cathode end, fixed so as to prevent a discharge of the current round the tube, as this very often leads to perforation when working in a damp atmosphere, or when the atmosphere is highly electrical, and prevents the brush discharge round the bulb. The tubes that I obtain from Messrs. Newton are always in good condition, but for my purposes I still further condition them by heating and cooling. With this 20-inch coil † I can very often condition a tube in a few minutes, extending to thirty-five minutes. I am sorry to see so many experimental tubes with so much metal-work inside, as this is fatal, according to my experience, to the proper working of the tube; and the bulb of the tube should not be too large, as I have noticed that the nearer you approach the size of the original tube the better the results. Heating the tube during working saves the platinums of "make and break" of the coil. It has happened on several occasions that tubes would not condition for days. I, therefore, put them by for a rest of two or three months, and, to my surprise, they proved to be in good condition when tested. By the term "condition" I mean that the tube works with an almost straw-coloured anode, with a white-hot nucleus at the point of bombardment of cathode rays, even to a spheroidal condition due to electrical molecular tension on the surface of the anode, without any blue or magenta-violet phosphorescence behind the anode. Sometimes the phosphorescence behind the anode in consequence of the intense heat assumes a reddy-brown colour similar to a smoke-fog at sunrise or sunset.

It is at these critical points that the pneumatic buffer I have ventured to introduce at the Apps "make-and-break" is most useful, as the slightest pressure of the finger reduces the bombardment on the anode, and prevents the magenta phosphorescence evolving from the red-brown; the magenta condition, if allowed to continue for only a few seconds, will strain the tube too much and perforation will take place. Curiously enough the red-brown condition does not seem to interfere materially with the photographic action of the rays.

The electrical molecular spheroidal condition on anode on one occasion assumed such a globular form that I stopped working the tube, but could not obtain the same effect again.

Prof. Jackson informs me that he had noticed the same thing, and that in the spheroidal state the globular form had appeared and burst. The white spot on platinum sometimes assumes a double form like two miniature suns, the left sun being more accentuated than the right; in this case the diagnosis of the human frame is under the

* Batteries should not be half-charged, and care should be taken to have no sparking at brushes of dynamo, otherwise the charging will be unequal and plates damaged, besides wasting H-P. energy.

† The reasons for using a 20-inch coil are: that greater amount of current can be used without so much sparking at "make and break," as is the case with smaller coils, and it is important that the platinums should be kept flat at contact surfaces by means of a hard steel fine file in cases where the surface has suffered and become rough and oxidied; or after each use fine emery paper should be used to clear the surfaces.

‡ In heating the tube care should be taken not to allow the flame to play upon the bulb, but behind the cathode. As the tube approaches the desired condition it will be noticed that the rapping at the "make and break" becomes rapidly modified—sometimes producing a musical note. This is specially the case when using a ten-inch coil. Coils and tubes should never be run in a room laden with moisture, and by repeated experiences in giving lectures I know that it is dangerous to the insulation of coil and tube if ten or a dozen people are in a room, twenty feet by thirty feet, unless it is frosty weather. An electric fan, running so as to extract the air from a room where an audience is present, makes a great difference in the working of the apparatus. The tubes I shall use this evening are not protected, so that spark from anode to cathode can pass outside, and it is possible one may perforate.

most favourable conditions. It was with this condition that I took the photograph of trunk—in three minutes—which I now pass round. On disconnecting the tube and measuring the spark between dischargers on 20-inch coil, I found it to measure five inches; ampère current through tube being four.

Sometimes the double spot is not steady, and in that case the right hand produces rays of so penetrating a character that metals one-eighth of an inch thick become transparent, and the trunk of the human frame practically transparent, with incomplete display of the anatomy, the left-hand spot giving rays that will show every bone, and in the case of females the shadow of uterus.

The common phenomenon in working is a shifting spheroidal spot very often like a miniature nucleus of a comet. On heating the tube behind the cathode (preferably with a spirit lamp, as being less likely to crack the glass) this spot moved simultaneously with the movement of the flame of a spirit lamp which must always be kept in motion to avoid accidents. The heat rays register on a black bulk thermometer, in vacuum, five inches from tube, about an average of 10° in as many minutes.

Before I adopted the plan of heating the tube when in work, I never noticed any action of the rays on the skin, nor did Dr. Moore, with whom I was working; but in October, 1896, while heating the tube, my right hand was attacked by the rays similarly to sunburn, and afterwards, by constant exposure, the nails of the thumb and second finger died, being replaced by new growths. My right hand used to be affected with gouty eczema, about twenty-four years' back, when the nails came off in a similar manner; the left hand was not affected in either case. I have since used a metal guard over handle of spirit lamp. (Exhibited.)

I will now show you the human trunk, etc., on the screen, with a conditioned tube, when the pulsation of the heart will be seen; or, if anyone in the room has an aneurism, it will be detected, also tubercle in diseased lungs, provided the moisture in atmosphere of room is not too great.

At the end of April, 1896, I first noticed the action of rays in relieving rheumatic pain at elbow joint; since then, several cases have occurred. In one case in which I succeeded in getting the dura mater of brain after several unsuccessful exposures, the hair of the subject on side of head turned grey, came off, and ultimately grew again, the natural colour. I have noticed that my right hand is affected by the alkalies used in photographic developers; methol produced parchment-like condition of the skin, and amidol severe irritation. In this condition, when the hand was near the rays, I experienced a pricking, burning sensation. I therefore conclude that the rays only affect unhealthy skins, or skins affected by alkaline washes or soaps. A case in point was one in which the right shoulder and breast of patient were affected after three exposures, and I remember the patient said she was using a lotion to alleviate pain. The rays affect subjects by a sensation of heat or cold. Subjects with advanced gout are very impervious to rays—even in the arms.

The negatives I have for exhibition are all taken on Cadett's lightning and professional plates, except one of a trunk taken on a Sandall plate. To produce the best negatives it is necessary to have considerable experience in photographic development of snap-shots, especially with clouds. Having photographed for twenty-five years, I am well versed in most tricks of the trade. I use almost any developer, but especially amidol with bromide and rodinal with after use of hydroquinine.

For X ray snap-shots amidol is the best, and no caustic soda must be used, or fogging and thinning of detail will probably result. I may also add that I never use a developer full strength, but start with it from one-fortieth to one-fifth normal and strengthen up as required. Methol with hydroquinine is a good developer if used carefully, but will not keep long. Pyro is of course good, but amidol and bromide give similar results with much more detail. The six plates wrapped in black bags which I have with me are brought so that I can demonstrate the part of exposures of one-half or one second, when, if any one cares to take an exposed plate and develop in his own dark room, it may be interesting to note the development by different workers, and exhibit at some future meeting.

Mr. Ernest Payne (Brighton) asked what voltage was used by Mr. Webster to get the "sun" and other effects described; whether his hand had been injured only when the tubes were heated, and if he had tried to skiagraph spinal deformities.

Mr. Webster said he found twenty-four volts gave best results with his large coil. His hand had become inflamed only when he took to heating the tube; now he protected the hand by a metal shield over the spirit lamp. He had not tried spinal deformities, although he had taken several normal spines. The lumbar region was especially difficult.

* An inductive outside cathode is useful with tubes showing eccentric discharge. I have occasionally used this since January, 1897, it is made of aluminium, and fits the whole of tube, at back of interior cathode it is electrically connected with cathode wire.

Dr. WALSH asked if Mr. Webster would tell them something about the so-called "singing" anode.

Mr. WEBSTER said that the phenomenon occurred when the tube was active and penetration good; the favourable condition was a singing anode without much phosphorescence. Like Prof. Thompson he had not observed this phenomenon with a red-hot anode. He did not agree with Mr. Swinton's term, "rattling" anode, as sometimes he had recognized two notes, "G" and "B flat." On careful examination with a glass he could not detect any vibration of the anode wire.

Mr. CAMPBELL SWINTON asked if the double white hot spot mentioned by the lecturer was due to varying electrification of the glass and varying refraction.

Mr. WEBSTER stated that the shifting spot followed the motion of a spirit lamp beneath the cathode end of tube.

The PRESIDENT asked if Mr. Webster could throw any light upon the production within the tube of patches of phosphorescence.

Mr. WEBSTER could not explain the phenomenon, but agreed with Dr. Wolfenden that the tube did not act well when those patches were present, and they disappeared on applying heat.

Mr. SWINTON said that there were still many points with regard to the tubes that wanted explanation. For instance, what was the path of return of the molecules—the mechanism of the process?

The PRESIDENT pointed out that Sir William Crookes had demonstrated the molecular path.

In reply to Mr. Isenthal the LECTURER said for photographic effects he preferred rapid vibrations to slow. In taking snap-shots he placed the negative on a thick glass plate, and in that way got far better detail than when the negative was placed on wood or metal. Generally, he insulated everything, such as chair, coil, plate.

Mr. ERNEST PAYNE observed that when a battery was nearly exhausted, so that it if would not run with ordinary break, it would always run with a mercury break.

The PRESIDENT then moved a vote of thanks to the lecturer, which was carried with enthusiasm. Owing to the lateness of the hour, and the large number of tube and lantern demonstrations, the discussion on the paper was somewhat curtailed.

"INTENSIFYING" SCREENS.

Note by R. NORRIS WOLFENDEN, M.D.Cantab.

THE efforts of all workers in X ray photography have for some time past been directed towards the devising of means for shortening exposures. One means to this end is by improvements in tubes and manipulation, but another has been in the employment of screens of fluorescent salts to intensify or hasten exposure. The term "intensifying screens," which has been applied to these devices, appears a little inappropriate and inexact.

We are, however, all aware of what is meant by such, and there are probably few of us who have not, even long ago, been captivated by the idea and made application of some such screen in the hope of reducing the necessary exposure, and it is probably not incorrect to say that these devices have ended only in disappointment. Of the various salts that have been employed for this purpose, only one—viz., calcium tungstate—seems to have survived the test of experience; and in this, as with all other prepared screens, even where success has been attained in the shortening of exposures, there has been experienced one great drawback to their use, viz., the impossibility of getting rid of the granular appearance produced by the screen upon the photographic plate.

Twelve months ago I tried barium platino-cyanide screens with disappointing result; but the revival of the interest in the question excited by reports from Germany caused me to make a number of fresh experiments, which I have conducted now for three months, and, as I am asked to contribute a note to the present number of the ARCHIVES, possibly my experience may be interesting to some of its readers.

I have experimented with screens made of tungstate of calcium, barium platino-cyanide, the double fluoride of ammonium and uranium, and rubidio-lithium. Of these, I found the ammonio-uranium the most active, but the employment of these screens was rendered useless by reason of the granulation produced on the picture, completely destroying its value as to fine detail. I consequently abandoned their use, utterly discouraged; but the excellent effects said to have been obtained by Dr. Max Levy with tungstate screens used in connection with specially prepared plates caused me to recommence experiments. I obtained the Kassettes and screens direct from Dr. Levy, and a number of plates and films from Germany. I hold no brief for Dr. Levy, and have endeavoured to submit his method to as impartial an experiment as possible. This I have

done by comparing the photographs obtained with his screens and plates and films in nearly every case, with photographs obtained by using plates with and without screens, of the best known English and French makers. I need not particularize since there are so many excellent plates now on the English market. I will only say that I have not found any such marked differences between the so-called isochromatic plates and ordinary quick plates as to lead to any marked preference for the former. I must also say that I am inclined to agree with Levy, who remarks that his experiments do not lead him to support the statement of Cowl that the sensitiveness is increased by thickly coating the plate with emulsion.

A careful perusal of Max Levy's paper* has favourably impressed me with the modesty of his contentions, and though my earlier experiments with his screens and films was rather unfavourable, my later experiments have convinced me of the great advantages of using his method in surgical diagnosis, where shortening of the time of exposure is of importance. Thus I have obtained a very fair photograph of the thorax in forty seconds, and an excellent photograph of the face, exhibiting the frontal and maxillary sinuses in one minute, and a fair photograph of the larynx in one minute. These results could not have been obtained with ordinary plates.

For the photography of the portions of the body which do not require long exposures, *e.g.*, hand and arm, foot and leg, I do not see much advantage in the use of these "screens"; but it is certainly of great advantage to be able to shorten the exposure to a minimum of the more inaccessible portions of the body. Consequently, within limitations, I feel bound to speak very favourably of Max Levy's plates and screens as accessories in surgical diagnosis by means of photography. Unfortunately, there is some "grain" produced on the plate by even these screens, though it is much less than with any I have used, and it seems impossible to get rid of all traces of this. It leads to a certain degree of "fuzziness," which, however, is not sufficient to destroy the value of the picture, but undoubtedly, if we want to produce fine photographs, we must do it without the employment of screens.

As an abstract of Levy's paper appears in another portion of these ARCHIVES, there is no need to refer here, in detail, to his method. His specially prepared plates and films are coated on each side with sensitized gelatine. At first sight it does not seem easy to explain the advantages of this, and it would seem as if the shadow produced on the lower surface of the plate would end in "fuzziness." Levy's contention is that the second shadow intensifies the first. There is no doubt that these double-coated plates shorten the exposure very considerably, and if used without screens, probably to half the usual time. It has been suggested that the double-coated plate itself acts as an intensifying screen. It is known to be a property of some photographic plates to fluoresce. Shelford Bidwell† believed the seat of this fluorescence to be in the glass, since neither bromide iodide nor nitrate of silver nor photographic gelatine possess the property of fluorescence. Almost any specimen of glass, according to Bidwell, will, with a good, tube fluoresce sufficiently to enable one to see coins in a purse, etc., by employing it as a screen. Of course, these screens and plates will be of no assistance where the ordinary rules as to manipulation of tubes, coils, etc., are not obeyed.

* I find also that using these screens with Paget 50 plates the exposure is lessened by half, and in the case of the ankle one minute was sufficient to produce a strong picture full of detail and contrast.

† *Nature*, June 4th, 1896.

Notes and Abstracts.

Still Wanted—a Name.

For X ray photography the word *Diagraphy* is suggested by Dr. Max Levy, and *Diascopy* for screen work. The word *Actinogram* is sometimes used. For the science of measurement by Roentgen rays Dr. Hoffmann suggests *Skiametry*. Some may prefer *Radiometry*. Whatever word be eventually chosen, it ought to contain a common root and be applicable, by varying its terminations, to screen work, to X ray photography, to X-ray therapeutics, and to measurements by X rays.

Special Plates and Special Developers.

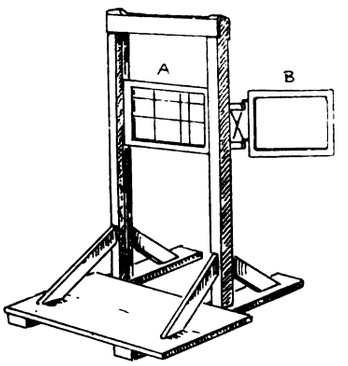
After various experiments to determine the best kind of dry plates for radiographic work, Dr. B. Larns has come to the conclusion that, at present, none of the "special Roentgen emulsions" offer any advantage over the ordinary dry plate, so long as the latter is of the highest sensitiveness for light and is rich in silver.

He recommends, however, a new method of development, as follows:—Development to begin with *hydrokinone*-potash

formula, and continued until outlines are pretty well marked. Plate to be removed into *metol* potash developer, which quickly brings out all details, in addition to the density obtained by the *hydrokinone*.

A Stand for Radiography and Screen Work.

The *Deutsche Medicinische Wochenschrift* for December 9th contains a paper by Dr. Aug. Hoffmann, of Düsseldorf, describing a convenient and simple form of stand for taking radiographs and for screen observation. The form of the stand will be understood on reference to the figure. Two uprights



A Stand for Radiography and Screen Work.

are fixed to a suitable base, with a board about three feet square, on which a chair can be placed for the patient or on which he can stand, as required. A frame A slides on guides between the two uprights ; A carries also a second support B, into which a fluorescent screen or a plate holder is placed. The frame A is fitted with wires, which can be adjusted in different positions to correspond with the shadows thrown upon the fluorescent screen. The screen is then removed, and a plate substituted if a radiograph is required. The frame B is fitted on hinged supports, so that it can be turned away from A if required—as shown in the figure—and brought back into position. The author finds the wires very useful in forming an estimate of the dimensions and—in the case of the heart and diaphragm—the movements of the parts under examination. By adjusting the tubes in different positions, and by moving the wires to correspond with the shadows, the author is able to make measurements and, in some cases, localize hidden objects without the aid of photographic plates.

The tube is held in an arm fixed to the cross-piece at the top of the stand (not shown in the figure). The arm is adjustable so that the tube can be placed in position on the other side of the patient, so as to throw the shadows on the frame A and on the frame B when turned into position behind A.

A "Bullet Detector."

M. Contremoulins, of Paris, has designed a special form of apparatus for localization of hidden objects (*le chercheur de projectiles*), and has used it successfully to determine the position of bullets in the head, which have been extracted by M. Rémy. The apparatus consists of three separate parts. The first is a framework that can be fixed in position on the patient's head, and carries three adjustable arms that are made to rest firmly against the bones of the face—for instance, one on the forehead and one against each cheekbone. The framework carries two tubes on one side and a plate-holder on the other. Two radiographs are taken, one from each tube. The second piece of apparatus is then brought into use. It consists of four adjustable arms mounted on a stand, the extremities of which are set in positions corresponding with the three points on the patient's face, above referred to, and with that of the bullet. The position of the bullet is determined by threads arranged to represent the path of the rays, the position of the same being given at the point where the threads cross.

In conclusion, a special form of compasses are employed, which is set to correspond with the three points on the face and the centre of the ball, and then transferred to the head of the patient. The arm indicating the position of the bullet points directly at the latter ; and the distance through which this arm is raised before it can be placed on the patient's head indicates the depth of the shot below the surface. An adjustable stop is fitted on this arm to show accurately the distance through which it has been raised.

Levy (Max).—*On Shortening of time of Exposure in Roentgen Photographs.* "Fortschritte der Roentgen Strahlen." Bd. I., Heft 2 and 3, 1898.

The larger the capacity of the inductor, the shorter in general is the exposure, provided the tube is suited to the length of spark. The interrupter is of great importance, both as to precision and number of the interruptions. It is certainly not true that photographic action increases proportionally to the number of interruptions. The number of interruptions should be such that flickering in the screen should be scarcely visible, and the right number is 1000-1200 per minute.

The tube and its handling is of essential importance.

For long it has been stated that the tube should only be used with the platinum glowing dark red. This is true of tubes of low spark length, but an essential increase of activity in tubes of about 15 cm. spark length is obtained, even two and three times strengthening, when the platinum is at a beginning white glow.

As to screens, of fluorspar, potash and barium, platinocyanide and tungstate of calcium, the latter is alone used to-day.

The comparison of an ordinary plate covered with one screen is as one to four, and as one to five or six with a film between a pair of screens, when a dry plate without screen and another with screen is exposed to the rays. The author has been endeavouring to get rid of the granulation seen with these screens, and has latterly so far progressed that nothing now stands in the way of the application of these screens to practice, especially in the photography of the deeper parts of the body, such as the chest and pelvis.

It is important that the screen should always lie close in contact with the sensitised surface, else want of sharpness results. This is best obtained by the use of flexible, not stretched screens, or by having them placed in kassettes.

It is erroneous to say, as Eder and Valenta have maintained, that extra-sensitised plates are not superior to ordinary plates in their activity to X rays. The most sensitive are the best for Roentgen photography. Cowl pointed out the sensitiveness is also increased by coating the plate thickly with emulsions, but Levy's experiments do not support this, and there is no difference between a plate coated four times and one single coated of the same manufacture. Levy employs plates sensitised on both sides. The rays pass unweakened through the upper sensitised layer, pass through the thin glass, and produce on the under layer a negative, nearly as strong as that on the upper surface. The lights and shades cover each other and produce an intensification. The latter is especially marked in films, and they will come to be used more frequently. An ordinary film and a Roentgen film exposed side by side show that when the latter produces a fully exposed picture the former shows no image at all. A shortening of exposure by 12-15 times is obtained by Roentgen plates, or, better still, films, when placed between a pair of intensifying screens, and this combination will be especially useful in cases where short exposures cannot be obtained, such as the thorax and pelvis. Pictures can be obtained in the former in 30-90 seconds, and in the latter in from 1-3 minutes. Pictures sharper and richer in detail are obtained by the resting condition of the patient, and skin affection are avoided.—R. N. W.

OPITZ.—*Three Actinograms of an Arterio-Sclerotic and One of a Preparation Injected with Grey Salt.* "Fortschritte der Roentgen Strahlen," Band. I., Heft 2 and 3, Dec., 1897.

A GOOD actinogram is one in which not only are bony structures clear, but also layer tendons and fasciæ, so that the picture appears "plastic."

He has observed that in many patients, whose soft tissues are not excessively developed, some give good pictures, while in others the actinograms are wanting in sharpness. The reason of this is unknown. It is not explained by the circulation, conditions, or pulsation of the living tissues, for simultaneously taken actinograms of a lower leg and hand exhibit no differences, even when one of them has had the blood driven out of the limb by compression; and the actinograms of the soft parts show no increase in definition.

He often has found a greater degree of definition in old than in young persons, even when the soft parts are thick. He believes that the sharpness of the picture is independent of the thickness of the soft tissues.

Very good definitions are obtained in arterio-sclerosis. Some excellent pictures are given by the author, in which the blood-vessels and tendons come out especially distinctly.

He also gives an excellent actinogram of an injected hand, in which the arterial system is figured to the minutest ramifications. He recommends the grey salt, which contains thirty-three and a third per cent. of mercury, and the portion of the cadaver to be injected is warmed along with the injection mass and syringe, in hot water.—R. N. W.

APPUN.—*On the Methods of Photography with the X Rays as Applicable to Medical Diagnosis.* "Fortschritte der Roentgen Strahlen," Band. I., Heft 2 and 3.

AN excellently written article, describing the methods necessary, very well worth perusal by a beginner, but containing nothing new.—R. N. W.

GOCHT (Hamburg).—*Pictures of Bone Structure by the Roentgen Rays.* "Fortschritte der Roentgen Strahlen," Band. I., Heft 2, 1898.

REFERRING to the method of preparation of bone given by Wolff in his work "Das Gesetz der Transformation der Knocken," the author gives the preference to his own method. The fresh bone is cleaned with knife and scissors from all soft parts, and cut in slices of ½-1 c.m. thick with a hand saw. It is then well washed, except in portions containing the marrow. The bone is then put on the photographic plate and exposed to the X rays, with a tube in which the focus is small and steady, at a distance of not less than 60 c.m. The light ought not be too intensive, and the exposure one and a half to two minutes.

In the case of vertebræ, which present projections laterally and backwards, a sagittal section is not to be placed flat on the plate, and it can be fixed down by a thread. A whole series of sections can be arranged on a single plate and simultaneously photograped. Maceration is not necessary; the method is very quick, and such pictures, which exhibit great fineness of detail, are very useful.—R. N. W.

Description of Plates.

PLATE XXXVI.

BONY ANCHYLOSIS OF THE KNEE.

By Prof. CARL BECK, M.D., New York.

The case is that of a woman thirty-four years old. She had been sick since being a child until fifteen years ago, when resection of the knee-joint was performed for tuberculosis.

There is considerable contraction, deformity, and shortening at present. Patient is in good health. The skiagram, by showing the presence of bony anchylosis, demonstrates the inadvisability of forcible stretching. The fibrous strings and the different shades of femur and tibia are particularly beautifully represented.

PLATE XXXVII. (*a*).

SHOT IN ORBIT.

By C. THURSTAN HOLLAND, M.R.C.S. (Liverpool).

A boy, seventeen years of age, had been shooting on September 13th, when a small shot from the gun of another of the party had struck him in the left eye.

In taking the skiagraph the patient reclined on his left side, with the left side of the face on the plate. The tube was placed in front of and above the face, and the rays directed slightly backwards so that instead of passing through the head—and thus both—from side to side, they passed through the nose and the left orbit only.

From the history of the case, and from some experiments made by placing a similar shot in different parts of a skull and taking skiagrams, the conclusion was arrived at that the shot was lying on the nasal side of the orbit, and had probably passed out of the eye itself.

PLATE XXXVII. (*b*).

A "LOCALIZATION" CASE.

By W. S. HEDLEY, M.D.

The leg in question is sixteen inches in circumference at the knee, and a veritable pincushion. I have already localized four needles which have been removed, but it is now evident that there are others lower down whose presence was unsuspected until the localizing radiograph was taken. The original picture (not here reproduced) gives, of course, a very misleading idea of the space occupied by these foreign bodies, as well as of their size and relative position; but it is interesting inasmuch as it not only reveals their presence, but to some extent explains how they got there. It shows at least one way in which they did *not* get there. The statement was to the effect that accidentally kneeling on a large bonnet pin, the latter entered the knee, breaking into several pieces. The radiograph shows, and examination since extraction proves, that there are more *points* than one. This fact refutes the idea that the occurrence was accidental in the way described, and brings the case into quite another category.

The localization was effected by the string method, with a small portable apparatus devised by the writer.

PLATE XXXVIII.

CASE OF VESICAL CALCULUS.

By R. LANE JOYNT, M.D., F.R.C.S. (Dublin).

Patient was a boy aged four and a half years, brought to the Meath Hospital presenting symptoms suggestive of calculus. A skiagram was taken, patient lying on his back. A penetrator tube, actuated by an eight-inch Yeate's coil, was used at a distance of eighteen inches from plate, exposure about fourteen minutes. The photographic plate was a "Cadett lightning."

With the kind assistance of Sir William Stokes I performed suprapubic cystotomy, and removed the stone, which weighed three drams. The patient made an uninterrupted recovery and left the hospital ten days later. In this case, of course, the X rays gave little more information than that which could be and was obtained with the sound; but they show approximately the size of the calculus. In certain cases where the operation of sounding the bladder is itself at times a serious affair, the X rays ought to prove valuable as an aid to diagnosis.

PLATE XXXIX.

ARRESTED DEVELOPMENT OF ULNA.

The case was one of an infant with very imperfect development of the ulna. As the first skiagram shows it consisted of two separate pieces. The upper was made up of normal bone, while the lower fragment was imperfectly ossified. The axes of the two fragments were not continuous. Owing to this condition of the ulna the radius was much larger, and the hand occupied a position of considerable adduction, while the head of the radius was dislocated outwards and upwards.

At the operation the ends of the bone were freed, and the fragments connected in continuity with wire. In order to strengthen what was a very imperfect bond of union, the femur of a rabbit was split into two and was wired on to either side of the ulna. There is nothing to say about the subsequent course of this case further than is shown by the skiagram, taken at an interval of about one month after the operation. Power and usefulness were increased considerably by the operation, while deformity was correspondingly diminished.

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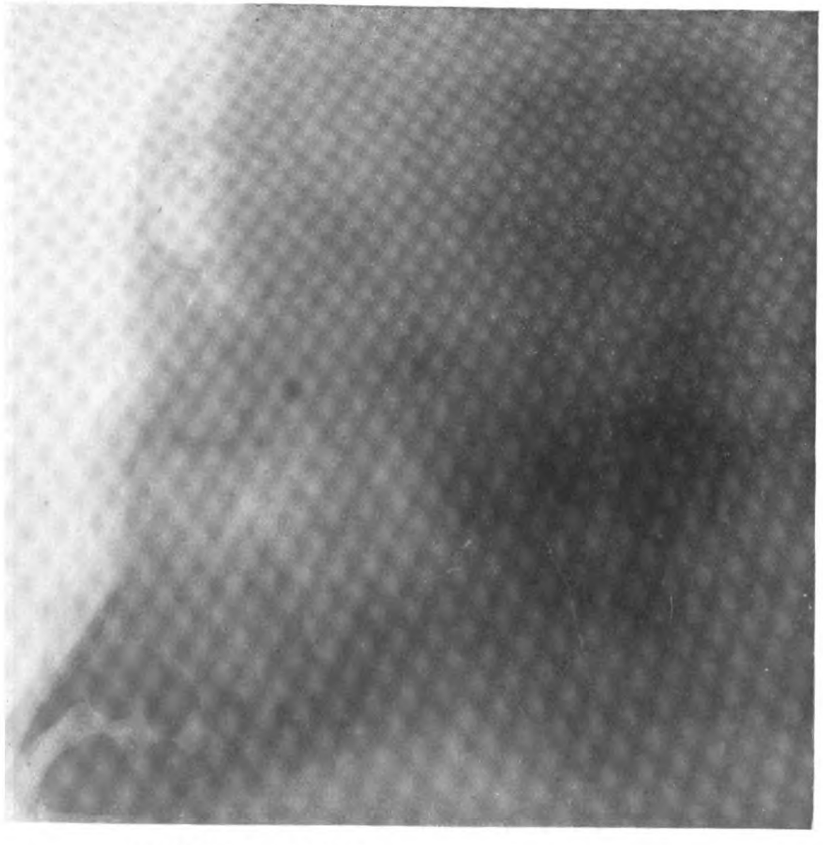
BONY ANCHYLOSIS OF THE KNEE.

(By Prof. CARL BECK, M.D., New York.)

PLATE XXXVI.

("*Archives of the Roentgen Ray.*"—*Copyright.*)

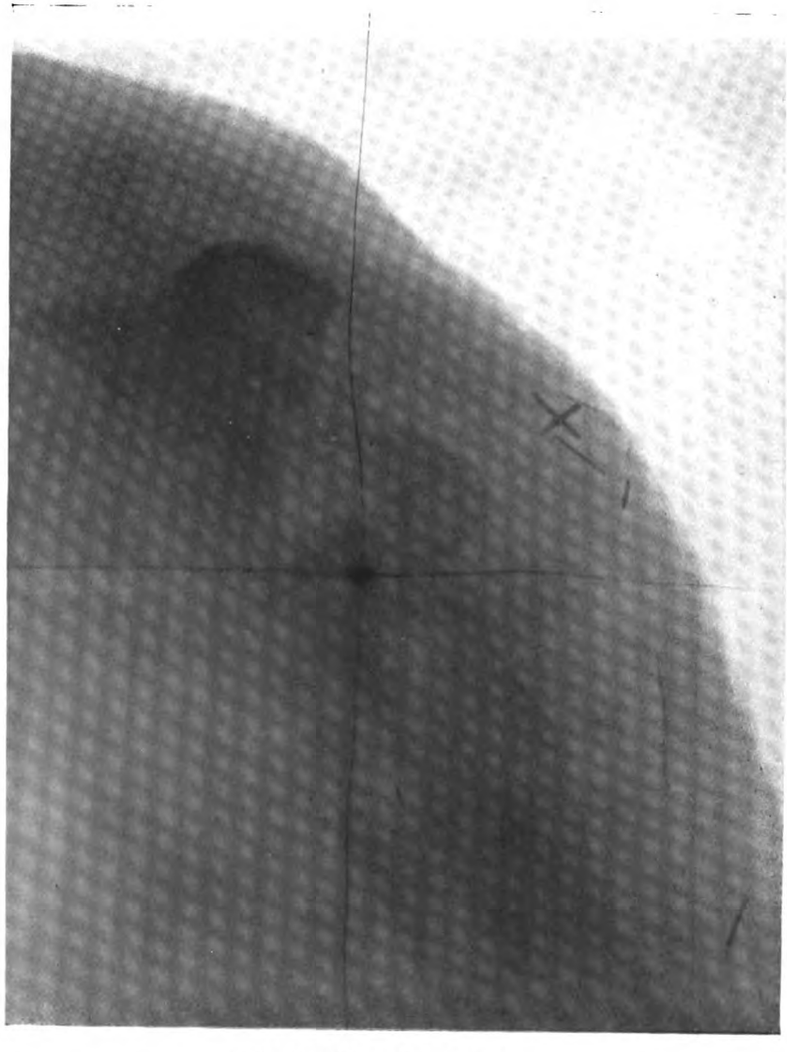


SHOT IN ORBIT.

(*By C. THURSTAN HOLLAND, M.R.C.S., Liverpool.*)

PLATE XXXVII (*a*).

(*"Archives of the Roentgen Ray."—Copyright.*)

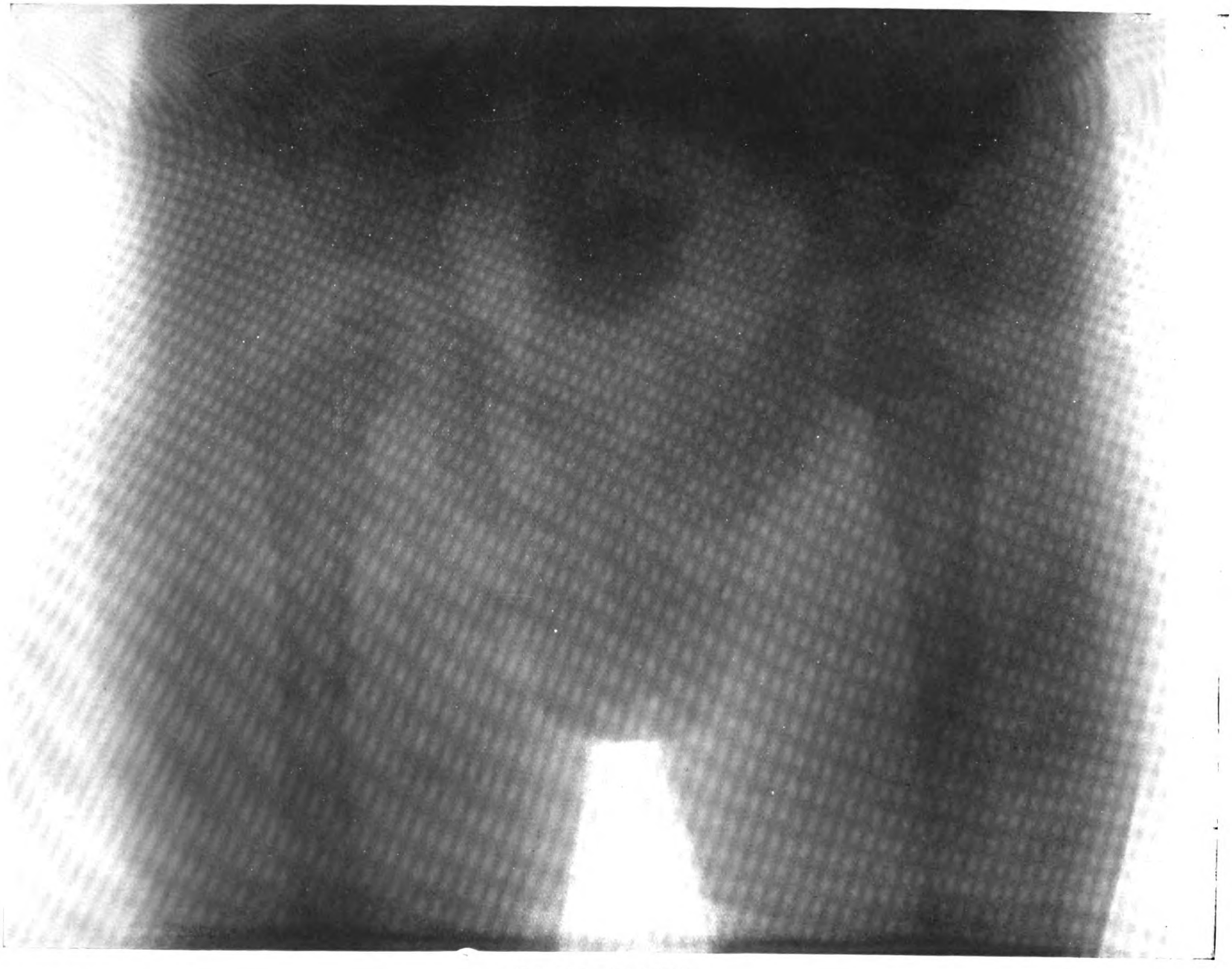


A "LOCALIZATION" CASE.

(*By W. S. HEDLEY, M.D.*)

PLATE XXXVII. (*b*).

(*"Archives of the Roentgen Ray."—Copyright.*)



VESICAL CALCULUS.

By R. LANE JOYNT, M.D., F.R.C.S., Dublin.

PLATE XXXVIII.

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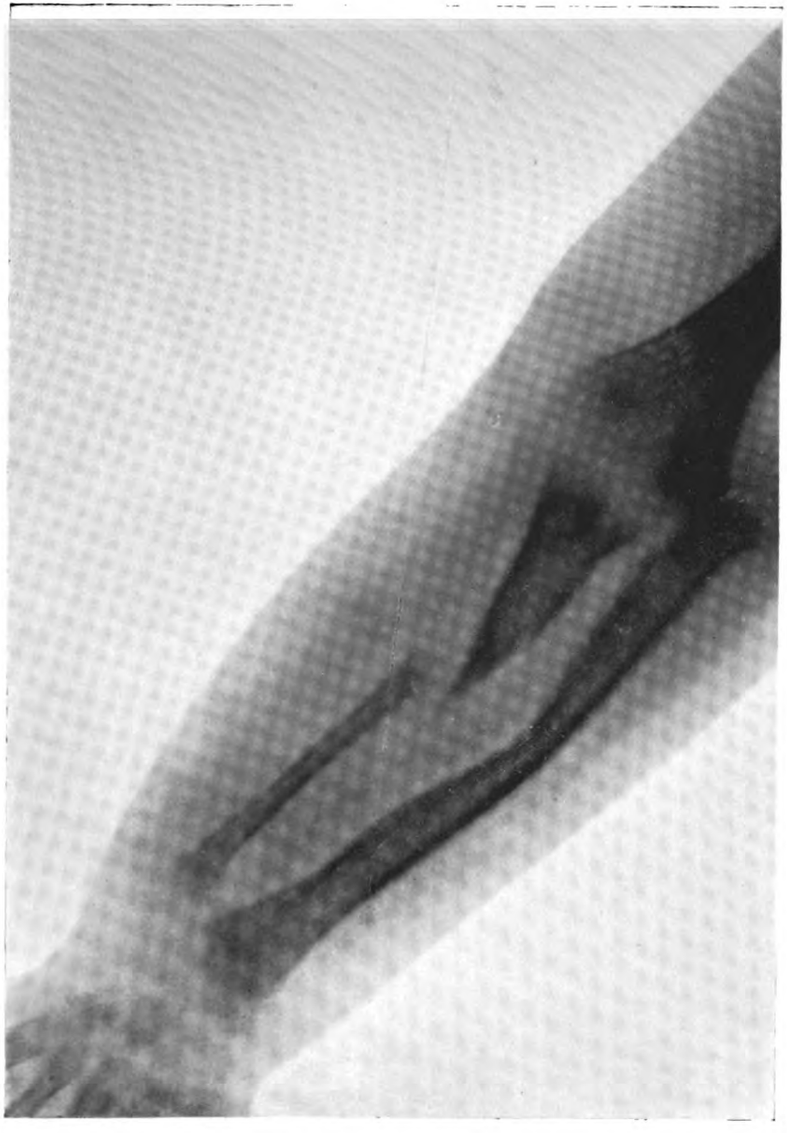
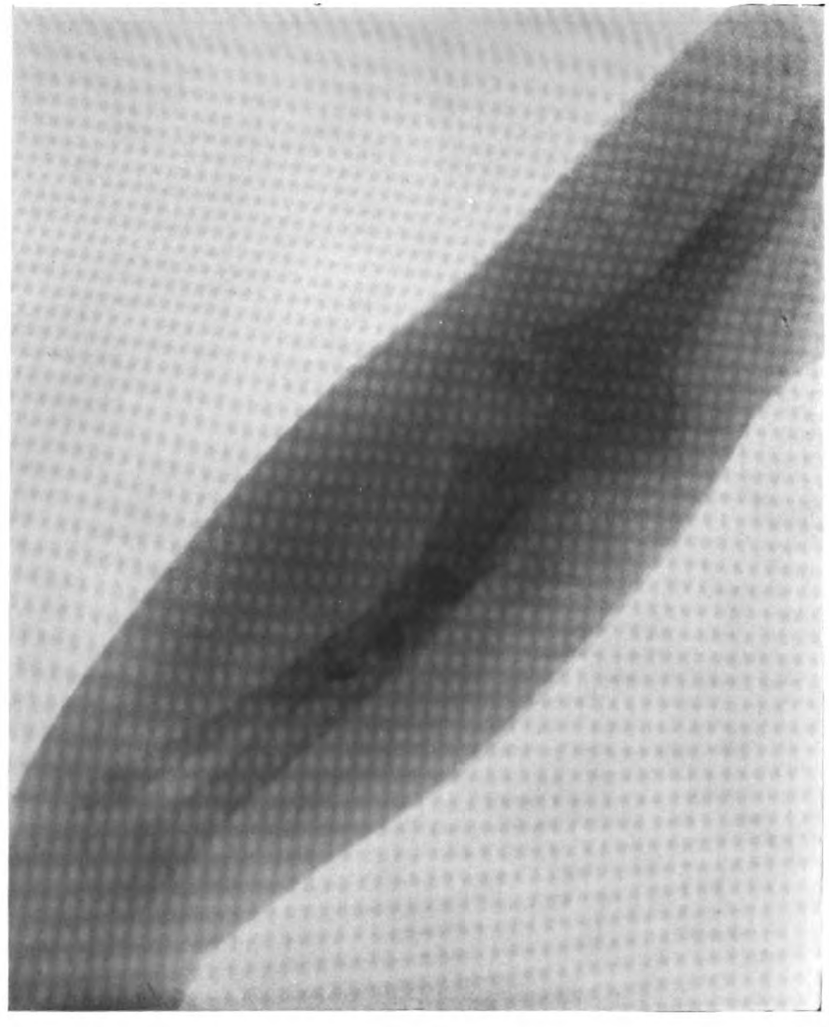


ARRESTED DEVELOPMENT OF ULNA.

(By W. WATSON & SONS.)

PLATE XXXIX (*a*).

(*"Archives of the Roentgen Ray."—Copyright.*)



THE FOREGOING FOUR WEEKS AFTER BONE-GRAFTING.

(By W. WATSON & SONS.)

PLATE XXXIX (*b*).

(*"Archives of the Roentgen Ray."—Copyright.*)

Vol. II.—No. 4.] MAY, 1898. [Price 4/- or $1.

ARCHIVES OF THE ROENTGEN RAY.

The Roentgen Society's Collection. It may be remembered that at the conversazione of the Roentgen Society, held last autumn at St. Martin's Town Hall, there were exhibited a large number of radiographs. In accordance with a suggestion made at the time, some of these were presented to the Society. It is hoped that they may form the nucleus of an extensive and representative collection, which will illustrate from the beginning the progress of medical and industrial radiography. Such a collection would be in the highest degree valuable for purposes of reference and comparison, and might eventually develop into a museum of everything that appertains to the Roentgen ray. There is room for systematic work of this kind in many directions. Thus, it would be interesting and instructive to have a complete series of radiographs showing the chronology of osseous development in the human subject. This should consist of views taken from two or more aspects of the bones and articulations, up to twenty-five years of age. Another such series might, by means of opaque injections, display the distribution of arteries; another group might illustrate fractures and dislocations. Gout, arthritis, calculi, intestinal concretions, aneurism, atheroma and calcification of arteries, diseases of bone, and perhaps in the future many pathological changes of soft tissues, would all be duly classified and made easy of access. Radiographic representations of other industrial or useful applications would be similarly dealt with. This is a field of work for the Roentgen Society to which every member can contribute something. Suggestions as to the safe keeping and arrangement of such a collection might be considered at an early meeting of the Society.

X Ray Traumatism. It was decided at a meeting of the Council of the Roentgen Society on April 5 to nominate a committee to collect information on the subject of the alleged injurious effects of Roentgen rays. This committee has prepared a set of questions, a copy of which may be obtained from the secretary, Mr. E. Payne, Hatchlands, Cuckfield, Hayward's Heath. These questions are framed with a view to elicit opinions as to whether in any given case the injury was the result of any of the following causes: (1) The X rays themselves directly. (2) Some electrolytic or electro-thermal action of a leakage discharge of current from the leads or from the terminals of the tube. (3) Some action due to the varying electrostatic charges on the surface of the tubes. (4) Some combination of these causes. (5) Some other hitherto unrecognised kind of radiation emitted simultaneously with the X rays. (6) Some other cause hitherto unobserved. The constitution of the committee and the list of questions is given at p. 92.

Is the Eye sensitive to Roentgen Rays? Our readers will remember that this was a question discussed in the inaugural address of the President (see p. 28 of the Archives) last autumn. At first it was supposed that these rays had no effect on the eye. Then Herr Brandes discovered that they can be faintly perceived in an eye that has long been kept in the dark, so as to be very sensitive. When this observation was first announced it was discredited by certain physiologists, who regarded the phenomenon as an illusion, or, rather, as a subjective phenomenon due to other causes. They considered it to be a "phosphene," that being the name given to the subjective appearances of light such as may be produced in total darkness by pressing against the side of the eyeball. In the particular case in question they suggested that this phosphene was produced either by stimulation of the optic nerve by the electric discharges in the neighbourhood, or else that it was due to a muscular effort within the eyeball itself, consisting of an attempt to focus or accommodate the vision—a sort of muscular effort to explore the darkness. Professor Dorn has, however, triumphantly refuted these suggestions, and established beyond question the visibility of the Roentgen rays. We have much pleasure in

drawing attention to his paper, recently published in *Wicdemann's Annalen*, a translation of which will be found on p. 69 of the present number of the ARCHIVES.

Coils and Interrupters. Under the title "Notes upon Interrupters," Dr. John Macintyre, F.R.S.E., read a paper before the Roentgen Society on May 10, in which he described a new form of contact-breaker, which had been constructed at his suggestion by Mr. Apps. A full report of this communication will appear in our next issue. The following is the syllabus circulated at the meeting:

Introduction.

1. Consideration of different types.
2. Advantages and disadvantages of each.
3. Special factors for X ray work.

Special Experiments.

1. Description of arrangements to ensure as far as possible the same conditions in a series of experiments, including currents, rheostats, measurements of volts, ampères, number of interruptions per second, coils, condensers, position of discharge rods, tube, screen (actinometer, etc.), switchboard to allow of instant changes of different interrupters, special form of interrupter.
2. Effects judged of by (*a*) measurements of current; (*b*) spark; (*c*) Crookes' tube; (*d*) photography; (*e*) screen, etc.

Special Factors

Considered in obtaining results: (*a*) rapidity; (*b*) intensity; (*c*) current.

Results.

In (*a*) ordinary work; (*b*) deep-seated tissues; (*c*) the great cavities of the body. [Photography and screen work.]

This was preceded by a paper on "Induction Coils," by Mr. A. Apps, which also will be reported *in extenso*.

The Royal Society and the Roentgen Ray. The Royal Society held the first of its two annual conversaziones on Wednesday, May 11, at Burlington House. The display of apparatus was large and varied, and the experimental demonstrations of their accustomed interest. But amongst much that was novel there was little that was absolutely new. From the standpoint of the ARCHIVES, it is necessary to notice only that part of the programme which appertains to the Roentgen ray. Mr. Campbell Swinton, of course, comes first with his most recent experiments bearing on electrical discharges in vacuum tubes. A very effective display was the production of light by the atomic bombardment of refractory material, such as lime. The latter was focussed between two concave cathodes in a vacuum tube; and it was shown by means of an attached pump that there was a critical vacuum, at which the best illuminating effect was produced. It was pointed out that the efficiency of such a tube was high (1 candle-power per watt), but that its life was necessarily short. In another experiment, by means of a radiometer mill-wheel fitted in an exhausted tube, it was shown that, when in action, a positively electrified stream from the anode travelled in an opposite direction to the cathode stream, but external to the latter, and sluggish in comparison therewith. Photographs of the anticathode, showing the active area of the latter and its effects, were most interesting and instructive. A pinhole-camera was, of course, used, and focussed on a fluorescent screen. The screen being withdrawn, a photographic plate was substituted. Several photographs of this kind were exhibited, showing that penetration is great in proportion to the smallness of the active area of the anticathode. It also appeared that Roentgen rays are given off from a considerable surface of the fluorescent glass of the tube. Mr. Wimshurst showed tubes excited by his influence machine, and exhibited a new tube-holder. The latter would appear to require considerable modification to make it useful for purposes of localization and radiostereoscopy; adaptability to both of these requirements is desirable in such an apparatus. A now familiar friend, the cross-thread localizer, again put in an appearance and was well received. Dr. Mackenzie Davidson also showed some radiographs taken stereoscopically. It may be remembered that radiostereoscopic pictures shown by means of a reflecting stereoscope were exhibited by Dr. Hedley at the conversazione of the Roentgen Society, held in November last, and afterwards at the Royal Institution.

THE ROENTGEN SOCIETY.

A GENERAL MEETING of the Roentgen Society was held at 11, Chandos Street, Cavendish Square, London, W., on February 1st, 1898. Prof. SILVANUS THOMPSON in the chair.

The SECRETARY read a communication from Dr. Marsh (Northwich). A radiogram taken of the hand of a girl of seventeen showed a rounded mark, the size of a

small shot, over the distal end of the fifth metacarpal bone. This mark the operator concluded to be due to a defect in the negative. Seven months later he had occasion to take a Roentgen ray photograph of the same hand, and found the mark again. On the second occasion he ascribed the appearance to some peculiarity or lesion of the bone.

Mr. WATSON BAKER had observed a precisely similar mark, but in his case it appeared to shift its position somewhat in several radiograms taken of the same hand. The latter appearance might, of course, be due to altered relative position of hand and tube.

At the close of the meeting, Dr. MONTAGUE MURRAY pointed out the same spot in various skiagrams of hands lying about the room.

Dr. DAVID WALSH then read a paper on "Periosteal and other Soft Tissue Shadows."

Certain appearances, he said, met with in the Roentgen ray photographs of fractures led him to make some brief experiments, the results of which might have a suggestive value in the reading of the records of those particular injuries. The soft tissues photographed were taken from the tibia and ankle-joint (or hock) of the ox; they included periosteum, tendons, and bones.

Periosteum.

It might be stated that the periosteum from various parts of the ox tibia varied in thickness and density to the rays. Thus a strip from the posterior surface was thicker and denser than one from either of the two anterior surfaces. Again, the periosteum was much thicker over the insertion of muscles. This fact was well shown on a negative which had the shadow-picture of a strip of posterior periosteum, at one end of which was inserted for about half its breadth the tendon of a powerful muscle. At that point the periosteum was stripped from the bone with so much difficulty that it seemed doubtful whether some of the underlying bony tissue were not detached at the same time. Whether that was the case or not, the resulting shadow with the rays revealed a far greater density over the tendinous insertion than was the case with ordinary smooth periosteum.

On the same plate (A) an oblong sheet of periosteum was folded at one end so as to project a shadow of multiplying thickness upon the sensitive plate. It seemed to show that although periosteum was a thin membrane, yet it had a relatively dense shadow. This fact was further illustrated by the record left of the twisted and coiled tag which had been fashioned at the other end of the strip of periosteum.

On another photograph was shown a section of triangular ox-bone, half an inch thick, and a tendon from the hock as nearly as possible of the same thickness. From one side of the bone the periosteum had been stripped; it had been left untouched on the side B, and its presence could be traced by a faint line separated from the shaft of the bone by a light interval; on the remaining side it had been partially detached and twisted into a tag. This radiogram appeared to show that a strip of fibrous periosteum, about as thick as a sheet of ordinary brown paper, threw as dense a shadow under the Roentgen rays as that caused by half an inch of another extremely firm and tough fibrous structure, namely, tendon.

In another photograph various portions of an ox's tail had been photographed by the rays. At the top of the picture was the figure of the seven terminal caudal vertebræ, dislocated and fractured with great force. The chief point of interest was connected with the small dark shadow to be seen on the apex of the angle formed by the fragments of a fractured vertebra. Dissection showed that record to be due to a splinter of bone, stripped of its periosteum to a distance varying from one to two millimetres. Above that dark spot another less dense shadow pointed to where periosteum and tendinous insertions (of muscle and ligament) had been thrown back in a fold. On that inner surface of the angular fracture the bone had been bared for a distance of six millimetres. Without going at any length into that aspect of the subject, it might be pointed out that information, if obtainable, as to the extent to which an injury had deprived bone of its periosteum, would have a distinct surgical value. At the lower part of the picture was shown a comparison of thick and thin periosteum from one of the larger tail vertebræ.

Ligaments and Synovial Membranes of Joints.

These were dealt with together, because they were practically one tissue so far as the surgery of joints was concerned. It might be stated briefly that they were very opaque relatively to other soft tissues. This was shown on a negative, where the thick posterior capsular ligament of the ankle-joint of the ox was compared with a strip of periosteum and with a large tendon from the same region.

It may be of interest to note that while carrying out these experiments the accidental shaking of a large tube caused a rattling metallic noise associated in the author's mind with what Mr. Webster called the "singing anode." These sounds were definitely connected with the shaking of the tube. They at once recalled the fact that on one occasion, when a similar noise was being emitted from a focus tube, the noise ceased for a time after the lecturer had walked across and shaken the floor near the tube. Dr. Walsh then hazarded the view that the phenomenon might be due to mechanical causes.

Mr. Swinton, perhaps, had some such idea in his mind when he stated, as he did at the previous meeting of this Society, that he should be inclined to call it a "rattling" rather than a "singing" anode. At the same meeting Mr. Webster said he had detected two distinct musical notes, "G" and "B flat." It seemed hardly likely that a gentleman of Mr. Webster's high musical training could be deceived upon a point of that sort. With some trepidation the author ventured to stray so far into the field of physics as to suggest that the phenomenon of the singing anode might have a double interpretation; first, the mechanical origin, or "rattle," doubtless due to vibrating terminals; secondly, the setting up of a kind of molecular hum in the tube by the passage through it of an alternating current.

Lastly, these few points with regard to certain of the soft tissue shadows have been laid before the Society in the hope that they might possibly suggest lines of future work. For instance, the relation of opacity to density in these tissues opened up a promising field. The subject was one that might well engage the attention of the Society, for it seemed likely that the future of Roentgen ray diagnoses in medical work would depend greatly upon advances in soft tissue radiography.

Dr. WALSH called attention to a fact mentioned to him by Mr. Cox, which seemed to have a practical bearing. Mr. Cox demonstrated the fact that a finger could be placed on a focus tube in action, connected with a 10-inch coil. The interesting observation that a flickering generation of kathodal rays could in this way be converted into a steady generation suitable for screen work could not be shown with that particular tube, as it already worked steadily. Dr. Walsh, however, had tested the result that afternoon, when the fitful illumination of a screen was rendered continuous and equable.

Mr. MOORE said that he had found the longer the exposure given to a limb, the less the tendons showed in comparison with what happened in shorter exposures.

Mr. WILSON NOBLE thought that the tendo-Achillis was more transparent than the flesh, and illustrated the point by a slide projected on the screen.

Dr. HEDLEY thought that soft tissue radiography depended upon conditions which soon perhaps would come to be definitely formulated. He believed that it was a question of wave-length, and that wave-length depended upon the potential employed and the degree of vacuum. When both the latter were low, waves were produced suitable for accentuating the contrast between hard and soft tissues. It has been suggested that when the vacuum of the tube is high, contrasts are less well marked, because the shorter waves generated are able to traverse the bones also. It has also been stated that, in dealing with thicker parts, well-marked contrasts may still be maintained by increasing the ampèrage, *i.e.*, by giving more rays, but of the same wave-length. But where it is desired to get definition in the structure of the bones, both potential and degree of exhaustion of the tubes must be raised, *i.e.*, the wave-lengths shortened.

Several other members spoke, and the PRESIDENT remarked that it was a well-known fact that the luminosity of a vacuum tube might be shifted by placing a finger on the surface of the tube. He thought it was also known that putting a piece of tinfoil outside the bulb near the kathode had the effect of virtually increasing the size of the kathode and of lowering the effective resistance of the tube.

The following papers were then read by James Mackenzie Davidson, M.B., C.M. London: (*a*) A Method of Localization by means of Roentgen Rays; (*b*) A Test for the Definition of X Ray Tubes.

Some practical method of localization had become a necessity. At first surgeons were quite content that a skiagram should reveal the presence of a foreign body, but as the novelty wore off and the use of the X rays became more extended, it was quite obvious that some means should be devised to enable the skiagraphist to decide the exact position, and if possible the size, of any bullet, needle, etc., embedded in the tissues.

The method I have devised, and will now describe, is based upon geometrical principles, and is not only simple, but gives extremely accurate results, if due care is taken

throughout in the necessary measurements and adjustments.

As the Roentgen rays travel in straight lines throughout their course, not being refracted or twisted in any way during their passage through media of varying densities, it was of course obvious to everyone that the first step towards any attempt at localization had to be the taking of two or more skiagrams with the Crookes' tube moved to different positions. This was attempted by either sliding the tube-holder horizontally, or else by taking one skiagram at a certain distance, and then

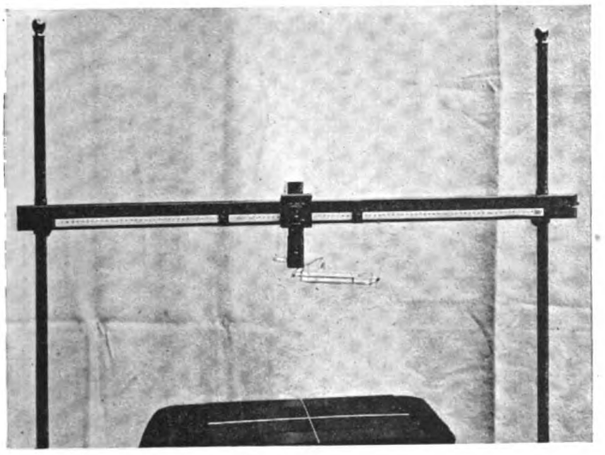


Fig. 1.

lowering it and taking a second one. With all these plans one relied upon arriving at a correct result by mathematical formulæ, or geometrical drawing to scale. My method reduces the matter to measurements solely, so that any ordinary skilled mechanic, accustomed to the use of a pair of compasses, a level, and a foot-rule, could carry out the process from beginning to end successfully.

The theory of the method is shortly this:—The Crookes' tube is placed in a holder, which can slide horizontally. A perpendicular is dropped from the point in the anode of the tube where the X rays originate on the point where two wires cross each other at right angles, and one of the wires must be parallel to the horizontal bar along which the tube-holder slides. So that when the tube is displaced along the bar, a perpendicular dropped from the X ray point in the anode would always fall upon this wire (see Fig. 1). The wires in reality represent two planes at right angles to each other, and to the photographic plate representing the third plane. Eventually I obtain the three co-ordinates of the foreign body from the three planes which are at right angles to each other, and whose relation to the part of the patient's body skiagraphed is known.

For practical purposes it is convenient to have the wires stretched across a flat board or sheet of vulcanite, and this can be placed on a table in the correct position below the horizontal bar, and fixed on to the table by means of drawing-pins (see Fig. 1). The wires being inked so as to mark the skin, a photographic plate, enclosed in black paper in the usual way, is placed beneath the cross-wires. The perpendicular distance from the anode to where the wires cross each other is carefully measured and noted.

It is now necessary to decide to what distance apart the tube is to be displaced in order to take the two skiagrams. It does not matter very much; $2\frac{1}{2}$, 5, or more inches displacement may be given. Having decided this, the movable clips (see Fig. 1) are so placed as to limit the sliding of the tube-holder to the required extent. The tube is then displaced to one side, and the patient places the part to be photographed on the cross-wires, being careful not to move once the skin has come in contact with the wires, because it is of the utmost importance that the shadow of the cross-wires on the negative should be in register with the ink-mark left on the patient's skin. Further, it is convenient to put a small coin on one corner of the plate, and also mark the patient's skin nearest to it. This reminds the operator as to the relation of the plate to the skin.

One exposure is made, and the tube is then displaced to the other side up to the clip, and a second exposure is given, on the same plate preferably, or upon a different plate, provided a suitable apparatus be used to enable the plates to be changed without disturbing the position of the parts at all.

Of course, it is open to the operator to employ any arrangement of sliding holder he may devise. In my first experiment I made the sliding arrangement out of three pieces of ordinary grooved casing, such as are used in electric light installations.

Having developed and fixed the negative, it will show a single shadow of the cross-wires, but two shadows of the foreign body. In order to interpret this correctly I devised the following apparatus, which may be called the "Cross Thread Localizer" (see Fig. 2). A sheet of plate-glass is fixed horizontally, having two lines marked upon its surface crossing at right angles in the centre.

A mirror hinged below it allows the light to be reflected from below so as to render details of the negative placed upon it visible by transmitted light.

A scale fastened to a horizontal bar slides up and down on two rods which support its ends. The scale has small notches opposite its marks. This is so placed that a perpendicular dropped from the O° or middle point of the scale falls exactly where the lines cross on the glass stage. Further, the edge of the scale is parallel to the line running right and left on the glass.

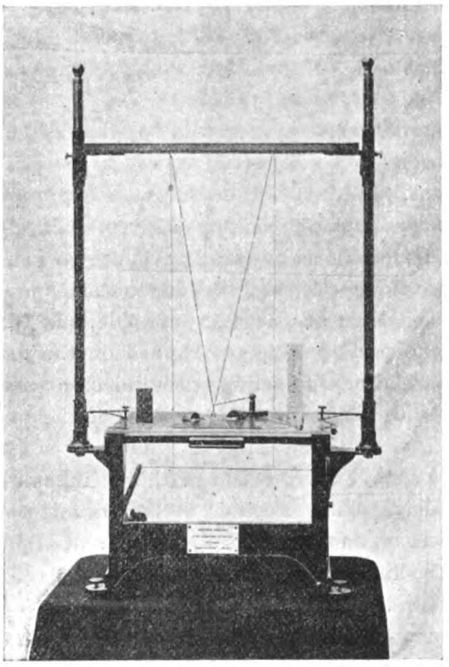


FIG. 2.

The negative is now placed upon this glass stage, being careful to bring the shadow of the cross-wires into register with the cross on the stage, and placed with its marked quadrant in correct position. The gelatine surface can be protected by a thin transparent sheet of celluloid.

The scale is now raised or lowered so as to bring the O° to precisely the same distance above the negative as the anode of the Crookes' tube was when the negative was produced. All that is now necessary is to place a fine silk thread through the notch on one side of the O° on the scale, and another thread through a notch on the other side, exactly the same distance apart as that which measured the displacement of the X ray tube.

Small weights are attached to the ends of the two threads to keep them taut, while the other ends are threaded into fine needles fastened to pieces of lead. Thus the needle with the thread can be placed upon any point of the negative and remain in position (see Fig. 2). In short, the negative is now relative to the cross-lines, the scale, and the notches from which the two threads come, exactly the same as it was to the cross-wires and Crookes' tube when being produced.

A needle with the thread is placed upon any point on one of the shadows of the foreign body, and the other needle is placed upon a corresponding point in the other shadow, and it will be found that the threads cross each other, just touching and no more. The point where they cross represents the position of the foreign body. A perpendicular can be dropped from this point to the negative below, and a mark made at the point where it touches the negative. Then with a pair of compasses the distance of this point from the two cross-wires can be measured.

The height of the point where the threads cross gives one co-ordinate, that is, the depth of the foreign body below the skin which rested on the photographic plate. The other two measurements give the other two co-ordinates. It will be obvious that these measurements can be noted thus (see Fig. 1).

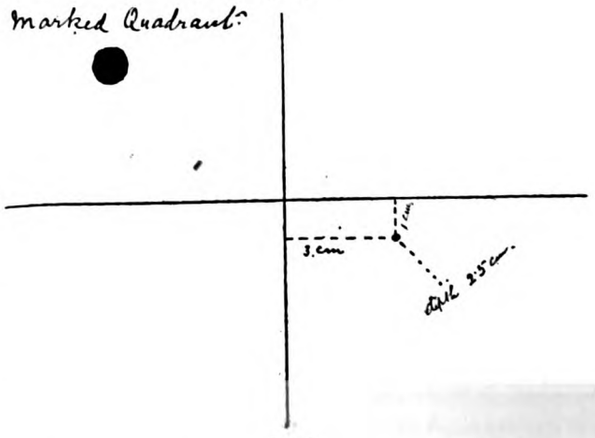


FIG. 3.

As the mark of the wires is left on the patient's skin, all that is required is to measure the two co-ordinates on the skin that give the point below which the foreign body will be found at the depth given by the third co-ordinate.

I have applied it in a great many cases, and it has proved exceedingly reliable, the exact position and length of the needle, etc., being found to be invariably correct.

Messrs. Curry and Paxton have constructed the apparatus for me.

Of course, it is easy for anyone to construct an improvised, simple, and portable apparatus to carry out my method, but for fine and accurate work a rigid and carefully constructed apparatus with levels, etc., attached is desirable.

But perhaps the practical possibilities of this method are best shown in ophthalmic work. I have applied it successfully in 20 cases of small pieces of steel in eyeball and orbit.

FIG. 4.

In the first case there was an error because I endeavoured to work from the plane of the plate resting against the patient's temple. Since then I always place a small piece of lead wire or foil on the lower eyelid. I then measure the three co-ordinates of the point of this wire which bears a known relation to the eyeball, and then measure the three co-ordinates of the foreign body. It is then easy to get the three minor co-ordinates which connect the position of the foreign body with the point of the wire (the position of this being known).

In several of the cases the particles of steel have been extremely minute. Some of them have been removed by the electro-magnet and the eyeball saved. In others, where the eyeball had to be removed, the measurements previously given of the position and size of the foreign body were verified to the minutest detail. A skiagram (Fig. 4) showing a piece of steel in the eyeball was shown, and the lead-foil upon the lower eyelid seen. Exposure with a tube with osmium anode was 90 seconds.

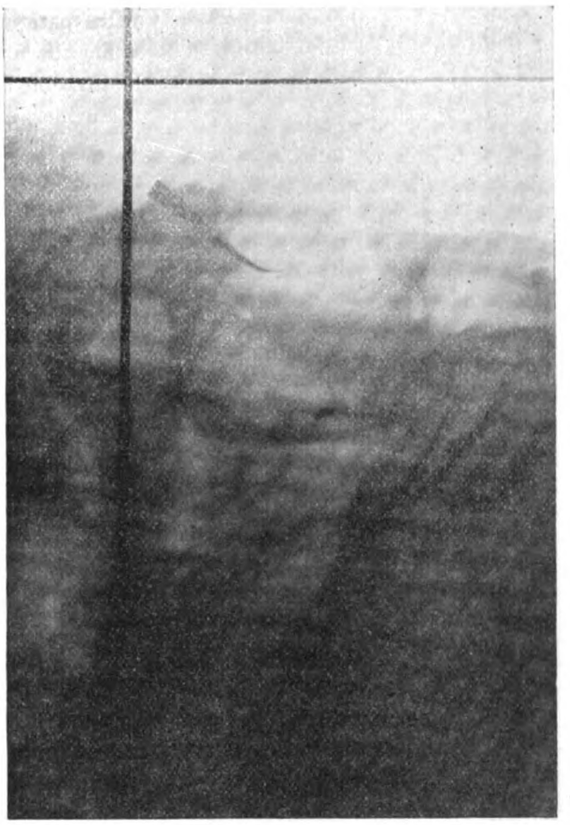


FIG. 5.

A skiagram (Fig. 5) of another eye case was shown. A Crookes' tube with an iridium anode was used. Exposure, two minutes.

I claim for this method that it is thoroughly practicable and reliable.

(*b*) A Test for the Definition of X Ray Tubes.

In order to get sharp skiagrams of minute particles of metal in the eyeball, a Crookes' tube had to be employed giving good definition.

Fig. 6.

Fig. 7.

I was so fortunate as to become the possessor of a focus tube which gave unusually sharp skiagrams (I bought it from Messrs. Allen and Hanbury, and I find Mr. Cossor, of 67, Farringdon Road, is the maker). In comparing this tube with others, I was led to adopt a simple and reliable test with a network of fine wires crossing each other at right angles, and 1 centimetre apart. Such a screen placed at right angles to the plane of the anode of a tube, and at about 15 centimetres from it, will cast a shadow on a fluorescent screen. If the X rays come from a very small point, the shadow of the wires will be correct. Anything larger than a small point will show astigmatism in the shadow; in other words, the wires parallel with the nearest edge of the anode will cast dark shadows, while the cross-wires will cast blurred and ribbon-like shadows, or even be invisible altogether.

Further, I took pinhole photographs of several tubes. The good tube I have referred to gave a fine sharp circle except for the shadow of a rivet.

The anode of this tube consisted of a small piece of platinum foil riveted on to a thick circular piece of aluminium. The kathode ray happened to strike one of the angles of the foil quite close to, and, indeed, partly on to the top of, an aluminium rivet. (See pin-hole photographs. These are two-thirds actual size of X ray producing-point. Fig. 6.)

Fig. 7 is an example of a tube giving bad definition and very marked astigmatic shadows.

NOTE.—Since I made this communication to the Roentgen Society, I have worked at this subject. Mr. Cossor has been indefatigable in making tubes experimentally to my instructions. The result is he can now make tubes where the kathodal rays come to a fine point on the anode, and these tubes give excellent results; but if strong currents are used, the platinum fuses or is disintegrated. Dr. Alexander Muirhead suggested using platinum-iridium anodes.

I tried iridium instead, which is superior in every way to platinum, but if a very strong current is used, the iridium anode becomes roughened at the focal point and fuses. I then tried osmium, with very brilliant results.

The skiagraph of a foreign body in the eyeball was taken in ninety seconds with an osmium tube. The strongest currents failed even to mark the osmium anode, but it is too soon for me to judge of the lasting power of this tube, as the vacuum seems to alter in rather an extraordinary way. Of course anyone trying osmium will have to remember it is only safe to heat it *in vacuo*, otherwise the poisonous osmic acid is produced.

ON THE VISIBILITY OF ROENTGEN RAYS.

By Professor E. DORN.

(TRANSLATED FROM THE GERMAN.)

DOUBT has been thrown* by certain physiologists upon the researches on the visibility of Roentgen rays carried out† by Herr Brandes and myself; while at the same time the opinion has been expressed that we had allowed ourselves to be deceived by subjective light-phenomena (especially by those termed "accommodation-phosphenes," arising from the muscular effort of focussing or "accommodation") and by electrical influences.

So far as any unprejudiced readers of our detailed article in the *Annalen* are concerned, these objections disappear of themselves. Therefore, I will not again refer to my refutation given in another place, but will only submit some experiments which, independently of their special bearing, may perhaps be of some interest.

The question whether the stimulation of the eye by Roentgen rays can be ascribed to the conjoint effect of a (muscular) accommodation and of a subjective sensation of light evoked thereby can be immediately decided by experiments upon an eye with paralyzed accommodation. Herr Schlodtmann, M.D., has had the extreme kindness to treat one of his eyes with homatropin, and to place himself at my disposal for observation. On May 25th, 1897, in the evening, by bringing his head, carefully wrapped up so as to exclude light, near to the Roentgen tube, the appearance of light was observed to be only a little weaker in the paralyzed eye than in the normal eye. At mid-day on May 30th the difference seemed more evident, but it disappeared after a sojourn—half an hour long—in darkness. It was, therefore, obvious that the paralyzed eye had been blinded by reason of the widening of the pupil in passing across the street in the bright noonday light. The stimulation of the sensation of light by the Roentgen rays resulted independently of the effort of accommodation.

With the co-operation of Dr. Dittenberger, I have made a series of researches upon the possibility of a stimulation of the nerves by electrical actions taking place in the neighbourhood of the head. A cardboard cylinder was placed over the head, and rendered light-tight by means of velvet. Under these circumstances it was definitely ascertained that the observer saw the Roentgen rays distinctly. An aluminium sheet, 1·03 millimetres thick, 60 centimetres long, and 45 centimetres broad, somewhat weakened the appearance when interposed, but did not produce extinction of the phenomenon. Then I allowed the sparks (10 centimetres long) of the induction coil, which had supplied the tube, to jump across the space previously occupied by the tube, at a distance of about 10 centimetres from the eye; *there was not, however, the faintest sensation of light.* Equally little was this the case when using a Himstedt's apparatus for Tesla currents, although I experimented with spark-lengths of 4, 6, 10, and 16 centimetres, and with horizontal and vertical positions for the spark-path.

Corresponding observations were made with another arrangement of head-covering—namely, black paper over the eyes, and velvet over the head—with similar negative results, in spite of the fact that in this case the length of the Tesla sparks was increased to 21 centimetres, and the observer was situated with the region of his eyes in the glow of the discharge.

The most striking refutation of the suggestion that the sensation of light excited by Roentgen tubes is an illusion due to electrical influences is, however, afforded by the following experiment:

The Roentgen tube was turned backwards, that is to say, with the back of the anti-cathode presented towards the eye. The eye, accustomed to darkness, could not detect the smallest action, although the appearance of light was distinctly seen, both before and afterwards, with the tube in the right position. The tube thus reversed in position produced only a very faint fluorescence upon a barium-platinocyanide screen.

Meantime, Herr Roentgen has himself confirmed the visibility of the rays discovered by him, and has given* an elegant modification of the fundamental experiment. If an absorbing metal plate with a narrow slit in it is held before the eye, there is perceived a bright line, which is either straight or curved according to the relative positions of anti-cathode, slit, and eye.

Before I had received information of this, I made a similar observation, in which I saw the "Roentgen shadow" of a straight brass rod 5 millimetres thick appearing under certain conditions as a curved shadow upon the retina.

The result of both experiments is easily explained. To me my experiment was important, because I perceived the curvature by observation without any previous de-

* See Proceedings of the Physiologischer Gesellschaft of Berlin, May 7, 1897.

† See G. Brandes, *Sitzungsberichte d. k. Akad. d. Wissenschaften zu Berlin*, May 7, 1896; also G. Brandes and E. Dorn in *Wiedemann's Annalen*, vol. lx., p. 478, 1897.

* Roentgen: *Sitzungsberichte d. k. Akad. d. Wissensch. zu Berlin*, May 13, 1897.

liberation, and the unexpected result offered, therefore, a welcome confirmation for the view that I was not dealing with an illusion due to subjective phenomena of light.

THE ROENTGEN SOCIETY.

A MEETING of the Roentgen Society was held at 11, Chandos Street, on Tuesday, March 1st, 1898. The President, Prof. SILVANUS THOMPSON, F.R.S., in the chair.

Minutes of previous meeting were read and confirmed.

The following were balloted for and declared duly elected: Prosper H. Marsden, M.D.; W. J. Paley Marling, M.A.; W. A. Coldwell; J. Morrison Barbour, M.D., F.R.C.S.; G. Paxton.

The following candidates were nominated, on the recommendation of the Council, to be balloted for at the next meeting: H. W. Cox, H. J. Loe, John H. Dudgeon, Miss Roma Austen, Miss Moberley, A. P. Sinnett, Dr. Heber Robarts.

Mr. Isenthal introduced M. Rochefort, of Paris, who demonstrated a new coil invented by him jointly with M. Wydts.

The Secretary showed a skiagram of double congenital dislocation of the hip by Mr. Noble Smith.

The PRESIDENT mentioned a case of writing submitted to him for Roentgen ray examination, and the matter was discussed.

Mr. ERNEST PAYNE suggested that in view of the importance of Roentgen ray dermatitis, a committee of investigation be appointed by the Society.

After some discussion, the further consideration of the matter was left to the Council.

The date of the next meeting was announced to be April 5th.

The following is a verbatim report of the paper read on "The Relation between the Photographic Activity and Penetration of Roentgen Rays generated at different vacua," by J. H. Gardiner, F.C.S.:

In the course of some recent work in the preparation of radiographs of reptiles and mollusca as an aid to biological research, many difficulties have been met with and overcome, and I thought that the experience in manipulation thus gained would possibly be of interest to the Fellows of the Roentgen Society, because the principles that govern the successful treatment of small creatures apply equally to all radiographs.

The specimens with which I have been engaged varied very much indeed in their character, and, to give some idea of the range of these variations, I have selected three specimen pictures, which I will project upon the screen.

The Common Newt.

This specimen gave the greatest trouble of any. The bone structure is exceedingly soft, and some of the parts, particularly the hands and feet, are very small, yet you can see that all the details, even to the smallest bone of the fingers, are quite distinct.

The second specimen, a frog,

Rana Temporaria,

is much easier. Here the bones are well formed, and present considerable contrast to the fleshy parts with which they are surrounded.

The third specimen is the shell of

Nautilus Pompilius,

measuring some six inches in diameter and three inches in thickness, having in its centre at least half an inch of solid calcareous matter, which has to be penetrated to bring out the internal structure. It was soon found that a tube that would give a good radiograph of the nautilus was unsatisfactory for such a specimen as the frog, and completely failed to produce anything but a flat, useless negative of the newt—in fact, it became necessary to find a particular tube to suit each class of specimen, and even then during work these tubes changed in their character, and could not even be relied upon to produce the same result on a given specimen twice. This gave rise to a good many experiments, first to decide upon the best form of tube for this class of work, and then to discover why it was that a given tube would successfully treat one specimen and fail with another. This suitability for a particular specimen was soon found to depend upon the vacuum, or state of the residual gas in the tube, and it was therefore decided to work with the tube attached to the air-pump, so that the vacuum could be kept constant or varied at will. In this way it was found possible to suit the tube to each specimen and to produce with reasonable certainty a good negative either of soft tissues or specimens of bony or calcareous nature.

The excessive beauty of Roentgen rays as a means of research in this direction is shown by the radiograph of the Discoglosus for osteological detail, and the Gecko, or night lizard, for details of the intestines and soft tissues.

So much by way of introduction.

Having thus arrived at a stage where we could produce satisfactory radiograms of these creatures to our hearts' content, it naturally became desirable to investigate the properties of the rays coming from a tube under different conditions of pressure, and to discover, if possible, an intelligent reason for the many early failures and more recent successes.

There are two properties of Roentgen rays upon which the preparation of a radiograph of a given object depends, **Photographic Activity** and **Penetration**; the first, their action upon an ordinary dry plate, which will cause it, when treated with a developer, to turn more or less black in a manner very similar to that produced by the action of ordinary light; and the second, the power that these rays have of penetrating more or less completely substances placed in their path.

These two properties, as is well known, vary with the position and form of the electrodes of the tube, as has been recently demonstrated by Mr. Campbell Swinton and others, by alteration of the gaseous pressure in the tube either by change of temperature or degree of exhaustion, and possibly in other ways.

They are also independent of each other. The first depends upon the length of time in exposure, and the second upon the state of the tube, and it is not possible with a state of tube corresponding to a low vacuum by any length of exposure to make a satisfactory radiograph of a specimen requiring much penetration. I hope by means of lantern slides to be able to demonstrate this presently.

I propose to-night to deal exclusively with changes in the character of the rays brought about by alteration of vacuum, with its attendant increase in the electrical resistance of the tube, the position and form of the electrodes and temperature remaining constant. As an indication of the state of rarefaction of these tubes, the plan has been sometimes adopted of giving the approximate resistance, as measured by an alternative spark between two electrodes in air; but as the resistance depends upon other things besides rarefaction, I have not relied upon this, and as the range of pressures within which all the changes in the character of the rays take place is very small, measurements of pressures in fractions of an inch or atmosphere are not satisfactory. But as the familiar appearance in the phosphorescence of the tube and of the residual gas is a sure and certain indication of the properties of the emitted rays, at least as regards photographic activity and penetration, I have taken this method of demonstrating the conditions of the tubes from the commencement of the production of X rays to the point just short of non-conduction. This range is shown in the five pictures on the wall, and I may say that after repeated experiments I find that these appearances are thoroughly trustworthy, and give an unvarying indication of the kind of rays emitted. They are numbered 1 to 5, and I will briefly describe them.

1. The path of the cathode rays seen in the faint gaseous luminosity comes to a focus just in front of the anticathode or target, which is uniformly red-hot. There is considerable gaseous luminosity round about and behind the target, the phosphorescence of the glass is faint, and the dark zone in the plane of the anticathode is just visible. The resistance at this stage is equal to three-quarters of an inch in air between pointed electrodes.

2. The luminous cone from the cathode has become faint and contracted, so as to appear almost as a straight line, forming when it strikes the anti-cathode a bright-red spot on the otherwise dull-red surface. There is more phosphorescence of the glass and less gas visible. The resistance has increased to equal one and a quarter inches air gap.

3. The cone from the cathode is no longer visible; there is a faint nebulosity in front of the anticathode; the phosphorescence of the glass is more brilliant, and the resistance has increased to equal one and three-quarter inches air gap.

4. The faint nebulous glow that in the last stage was seen in front of the anticathode has crept up the front and over to the back, finally detaching itself from the anticathode altogether, and forming a very faint cloud behind it. The phosphorescence of the glass is at its maximum, and the platinum target is red-hot only in its centre. The resistance has increased to equal three inches air gap.

5. A sudden change has now taken place. All trace of the nebulous cloud due to the residual gas has gone, the target is no longer red-hot, and the phosphorescence of the glass has diminished to about a quarter of its maximum intensity. The resistance has increased to equal four inches air gap.

These changes have been repeated many times, not only with one tube, by alternately letting in air and exhausting, but also with other tubes of the same pattern; and one has got so familiar with them that it has become

a habit to record the state of the tube as 1, 2, 3, 4, or 5.

Adopting, then, this means of indicating the state of the tube, to investigate the photographic and penetrative properties of the Roentgen rays coming from a tube in a given time in each of these five conditions, so as to be able to compare one with the other, several details have to be arranged.

1. There must be a means of arresting the vacuum at each of the five stages for the performance of an experiment, at the same time insuring against the gradual introduction of mercury vapour from the air-pump.

2. The character of the electrodes and the position of the tube with respect to the specimen under examination must remain unchanged, the sensitive plate only being moved.

3. The battery power feeding the coil must be constant.

4. The emulsion and sensibility of the series of the five photographic plates used in each complete experiment must be uniform ; and

5. The development of each of the plates in a series must be uniform also.

The first condition has been met by placing between the tube and the pump a valve that can be opened to increase or diminish the vacuum, and closed during an experiment, thus temporarily disconnecting the tube from the pump.

The uniformity of position and character of the electrodes has been met by employing the same tube for all experiments, and fixing the frame holding the specimen in its proper position immediately under the anticathode.

To obtain constant battery power was, of course, easy, and I need not occupy time about it, and uniformity of the plates and development was insured by making all five exposures upon one and the same plate, by means of a very simple piece of apparatus which I will describe.

The plate, in the form of a long strip, fits on a block that is capable of sliding in a straight path below a thick sheet of lead, having a small aperture or window cut from its centre. Light is kept from entering this window by a very thin sheet of aluminium foil; the thick lead effectually screens the plate from all the X rays except at the window, where, of course, the aluminium blind permits them to reach that part of the photographic plate below it. By means of graduation and a projecting arm outside the dark box successive portions of the photographic plate can be brought under the window without in any way disturbing the disposition of the apparatus with regard to the point from which the rays are proceeding or the object placed upon the window.

With these instrumental means it is possible to approach the first of the problems. The relative photographic activity of the rays produced at the five different stages, their point of commencement and duration, and the result, which I will show you in a moment, was as follows :

The commencement of the photographic action under these conditions is close upon stage 1, coincident with the first appearance of luminosity on a calcium tungstate screen, and the first indication of the dark zone in the bulb in the plane of the anticathode ; the activity increases rapidly and reaches a maximum at stage 4, coincident with the greatest luminosity in the green phosphorescence of the tube, and then suddenly falls off in just about the same degree as the falling off in the luminosity of the tube.

This lantern slide, as well as some of the others that will follow, is arranged so as to give the actual appearance of the negative ; each exposure corresponds to the state of the tube marked 1 to 5, the time in each case being sixty seconds, and the increase in electrical resistance is recorded on each.

The falling off at 5 is possibly largely due to the falling off of current passing the tube, because the resistance has increased so much that although the current feeding the coil may be constant, there is a great leakage in the conducting wires, and also in the coil itself. But the increase in the photographic density in from 1 to 4 cannot be due to this cause, for the resistance of the tube shows a gradual increase from stage 1. That there are other differences in the rays at stage 5, beyond a mere falling off in quantity, I shall be able to demonstrate to you presently, for the rays that have here produced a definite intensity of photographic action differ very much in their penetrative properties from those that in the same period of time have produced a corresponding photographic intensity at stage 3.

To get these results in a convenient form, I have, by means of an actinometer, or series of standard tints that I may perhaps describe at the end of this paper, obtained a numerical value for each tint, and have plotted them in a curve on a diagram, where the ordinates represent the intensity values, and the abscissæ the conditions of the tube, in this case due to alterations of vacuum. The property of penetration does not follow the same order

as the photographic activity, but, commencing at stage 1, increases without diminution to stage 5, and possibly beyond it. This gradual increase of penetration is shown in the next slide, where a whelk shell has been placed upon the window, and the same order of experiments repeated as last. Here it is seen that the penetration increases with the stages of vacuum, and in a marked manner **continues** at stage 5, where the photographic activity has fallen off, but this is better shown by a more simple object than a whelk shell. A wedge of bone was made, three millimetres thick at one end, and tapering off to nothing at the other. This was divided into six equal parts by thick lead wires, in such a way that each wire indicated a thickness of half a millimetre of bone. When placed in the path of the rays these lead wires practically stop all the X rays from getting at the photographic plate beneath them, and the limits of visibility of these screened parts, compared with portions of the plate not so screened, furnish numerical values for the penetration at the different stages. A series of pictures made with this bone wedge for an object shows again that there is no falling off in the penetration corresponding to the falling off of photographic action.

To show you that this excessive penetration is a property peculiar to rays generated in a tube corresponding to stage 5, and cannot be produced by lengthening the time of exposure at a lower stage, I have prepared another experiment with the same bone wedge, this time with the tube at stage 1, increasing the time of exposure from 1 to 4 minutes.

This slide also shows that the photographic density increases with the time of the exposure. The numerical value for this, and also for the penetration in the experiment before it, is given on the two diagrams.

Although these experiments make it clear that the rays from a tube at stage 5 could not by any condition of exposure or development be made to produce the same result as those from a tube at stage 3 or *vice versâ*, two confirmatory experiments were made with the newt which I first showed you as an object.

One is a series of increasing time exposures, the tube remaining throughout at stage 2, and you will see that, although the general appearance of the picture improves as the time is increased, the bone structures are badly marked, owing to want of penetration.

The next picture is a similar series with the tube at stage 5, and here the penetration is too great, there being complete lack of contrast in all cases. The fact is that, with such a soft, easily penetrated specimen, a good radiograph cannot be produced with a tube at stage 5.

Having attempted to demonstrate the differences in photographic activity and penetration of the rays coming from a tube in each of the five conditions shown, I have made three experiments to apply the knowledge thus gained. Combining the three curves of photographic activity, penetration, and time, on to one diagram, let us consider first the treatment of an object such as the newt, or any other soft-tissue specimen. As the most difficult thing I could think of, I have removed the hand from the newt and taken that as an object, parts of which are really microscopic, the fingers measuring not more than 3·5 mm. in length, 0·5 mm. in width, 0·25 mm. in thickness; but in this minute finger there is a complete system of bones so delicate that one would scarcely expect that they could cause any appreciable obstruction to the rays. Evidently the feeblest power of penetration is needed. I have taken stage 1, and to give sufficient density for a picture, the time was made eight minutes.

Another exposure—of course, on the same plate—was made at stage 5, giving three minutes to produce an equal intensity. It is not possible under these conditions to produce what one might call exhibition radiographs, but I think the result shows that with a low vacuum it is possible to deal successfully with such a minute object as I have described, and with a higher state of tube it is not possible.

As a second experiment, I have taken the trunk of the same creature, and as a little more penetration is needed, but not enough to obliterate the soft tissues, the kind of vacuum used was that described as No. 3, and the time of exposure three minutes, and another experiment at stage 5, giving four minutes, and I think it is clear that the advantage is with the lower vacuum.

And, finally, for an example of the other end of the diagram, as an object needing great penetration, I have taken the head of a bird—in this case the common Plover, having the tube at stage 5, while another experiment at a lower stage lacks greatly in detail.

Then followed a paper by Mr. Wilson Noble, "Some Observations on Various Makes of Tube and on Varying Conditions of Vacuum":—

In speaking of the various tubes on the market, it must be remembered that the opinions I offer are not to be considered by any means as conclusive, for, though I

have tried many kinds of tubes, I naturally have not been able to try many tubes of the same make, except in one or two instances.

As tubes of all makes vary one with another, it would be unfair to condemn a tube where only one specimen of a make has been tried. Again, as I have no pretension whatever to being a scientific worker, it is very difficult to arrive at a definite conclusion as to the behaviour of different tubes, owing to the difficulty of always obtaining exactly the same conditions of working. Tubes seem to vary from day to day, on account of the weather—never a matter of certainty in this country —affecting either the tube or the coil. Therefore the conclusions I have arrived at must be considered to be the result rather of general observation, than as having been determined by scientifically accurate experiments. If, too, I have occasion to differ from other workers, far better qualified to speak on the subject than myself, I can only say that the conclusions at which I have arrived are the result of my own experience, and that in a society like this, founded for the purpose of discussing an absolutely new power, the experiences of even a humble worker may be of value if they only show others the pitfalls to be avoided. Mr. Sydney Rowlands once said at the Camera Club, "I think that makers generally exhaust their tubes too highly." No doubt this opinion was formed because it was so often found necessary to warm a tube before good results could be obtained with it. I do not agree with this opinion, except with a reservation. I do not believe that any tube can be too highly exhausted, short of absolute vacuum, which, of course, is impossible. A tube may be undoubtedly too highly exhausted for the coil you are using, but that shows that your coil is not powerful enough, and not that your vacuum is too high. I believe a tube was taken to Mr. Wimshurst which would not pass the spark of an eighteen inch coil, and when put on to his large machine it was found impossible to turn the handle slowly enough to avoid getting the anode red-hot. From carefully noting the behaviour of very many tubes, I am forced to the conclusion that the higher the vacuum, the better.

If, however, you have a tube with so high a vacuum that a current will not pass, you have to warm it. Is the benefit that the tube thus derives due to the fact that you release a certain amount of gas occluded in the glass? I think not entirely. If this were all you did, you might as well have a tube with a lower vacuum to start with. I believe that the principal benefit derived is that the heat promotes activity among the molecules, and it is this activity which enables a current to pass and form cathode rays, the *fons et origo* of Roentgen rays.

I have come to this conclusion from the fact that if you have two tubes, working with a spark gap of say three inches, one of which has been warmed down to this resistance, while the other works at it normally, you will get a far better result with the former tube than with the latter, though the vacuum and resistance in each may, I presume, be considered the same. If this is correct, it would seem that anything that will produce activity among the molecules, other conditions being equal, is an advantage to the tube. It must be remembered that there are what I will call for convenience two kinds of vacuum. It is well known that the volume of gas is directly proportional to its temperature and pressure, and that you can either increase the temperature and pressure, leaving the volume unaltered, or increase the volume and temperature, leaving the pressure unaltered; and we also know that equal volumes of gas at equal temperature and pressure contain an equal number of molecules. It will thus be seen that you may have two tubes of equal volume and equal pressure, yet containing, if there is a difference of temperature, a different number of molecules. This is quite sufficient to account for the difference there is between two tubes, one of which has been warmed up to a certain pressure, while the other has the same pressure of vacuum at normal temperature.

The increase of pressure in a warmed tube is due to the extra rate at which the molecules of gas are travelling; and, travelling at this higher speed, they bombard the walls of the tube with a greater force. They will of course also bombard anything in the tube, such as the cathode, with an increased force, and in turn be driven from it at a greater speed, and strike the anticathode with more violence. If increased activity is all you want, it might be asked, Why not get this at once by having a lower vacuum; the molecules would still bombard the cathode more strongly, and be driven from it with the activity you require? So they would, but there would not be so many left alive to reach the anticathode, the mean free path being less. What you seem to want, therefore, is high activity among few molecules; a greater bombardment of more active molecules, rather than of more molecules in a less active condition.

Working, however, with a very high vacuum, there is

always a difficulty in getting a current through a tube, even if it is well warmed, therefore the current must be assisted by some other means. The size of the electrodes has a great deal to do with the free passage of the current. If platinum-wire electrodes are sealed into a tube, it is not a difficult matter to obtain a vacuum that will not allow a spark of several inches in length to pass; but if we increase the size of the electrodes, the spark will pass at once. Mr. Campbell Swinton has shown that it is no use increasing the size of the cathode beyond a certain point, as far as the emission of cathode rays is concerned, for in a high vacuum these are only given off from a limited area in the centre. I have thought, nevertheless, that though you may not increase the area of emission of cathode rays, yet you might, by increasing the size of both electrodes, facilitate the passage of the current, and so indirectly produce more cathode rays. I must confess, however, that my experiments in this direction have so far had but a negative result, owing perhaps to the difficulty in being sure of always getting exactly similar conditions without a properly equipped laboratory and workshop. It is very difficult, too, to get all the gas out of the metal of large electrodes, and also to know when it is out. The tube must remain on the pump for some days, for if sealed off too soon gas is sure to be given off later.

Tubes with two anodes give very good results in my hands, which I attribute to their being able to pass a large amount of current. I am also inclined to think that a large tube is better than a small one, but this may merely be a fancy; anyhow, I find they work more freely. By far the most powerful tube I possess, as far as penetration is concerned, is one of Hurst's, which is much larger than those usually sold. It has an extremely high vacuum, and I have never been able to bring the resistance down to less than a 6-inch gap. It, nevertheless lets the current pass freely, and gives extraordinarily brilliant results on the screen; it also has two anodes, which, as I have said, I find to be an advantage. About the photographic action of this tube I shall have something to say later on. I feel confident that with a 10-inch coil I am not getting all the power possible out of it, and am looking forward to trying it on a larger one. I have never been able to get the faintest glow of red on the anode; perhaps if I could I should get still better results.

A tube somewhat similar to this is one of Allen and Hanbury's; it, too, has two anodes, and gives results very similar to the Hurst's.

Another tube on a different principle is an American. It was described in the last number of the ARCHIVES. If the vacuum is too high, the current is passed by an alternative path, and, in so passing, warms some KOH, which gives off a gas, which reduces the vacuum to the necessary extent. When the tube cools, the gas, which I presume to be carbon dioxide, is supposed to be re-absorbed; but I believe I am correct in saying that dry KOH does not absorb carbon dioxide. But be this as it may, if the vacuum is once brought down, it does not get back again to its original condition. The results are, nevertheless, very good, and the screen is nearly as brightly illuminated as with the Hurst.

Another tube sold by Messrs. Watson is the "Penetrator." The one I have has some spongy palladium sealed in, which, on heating, is supposed to give off an occluded gas, thus reducing the vacuum; but I find the vacuum is more easily brought down by heating behind the cathode in the ordinary way, which, in my opinion, for the reasons already stated, is far preferable. The main defect of the tube is that it has a very thin anti-cathode, which is not an anode, and being isolated in the middle of the tube, has nothing to conduct away the heat, and consequently very soon becomes perforated. If it were brought outside the tube it could be used as a second anode, and a double advantage would be gained.

Another tube I have to bring before you is made, I am told, of didymium glass. It is made by Müller, after his usual pattern, and in no way differs from his other tubes, except in the composition of the glass. It is a very good tube, and will no doubt improve with use. Its main peculiarity is that it fluoresces red instead of green. I have tried to find whether this glass is more transparent to Roentgen rays than soda glass, but can find no appreciable difference.

These observations apply almost entirely to tubes in use with a screen, and it does not at all follow that the rays which affect a screen should also affect a photographic plate to the same degree. We have an analogy in ordinary light where the most actinic rays are invisible; so it may be with Roentgen rays, though it does not appear to me that these can be divided into visual and actinic rays—if I may be allowed the expression for convenience, though obviously incorrect—but rather into "penetrating" and "discriminating" rays. It is an easy matter now to get the rays through any part of the body, but it is by no means easy to get definition of the bones in the thickest parts. What radiographers want,

therefore, is to get tubes of good penetrating power and with plenty of discriminating rays. The two conditions might, at first sight, almost be thought to be contradictory one to another, because if you have a tube giving good penetration, and warm it down to give good definition, you certainly—at least, such is my experience—lose penetration. I think it cannot be doubted now that there are two kinds of rays, or perhaps I should rather say, rays of different wave-length, presuming the rays to be transverse vibrations of ether. As nothing can be said to be entirely opaque to these rays, is it not conceivable, when you use an extremely high vacuum, thus getting great penetration, that you are producing waves of such infinitesimally short wave-length, that they pass with almost equal facility through dense and light substances—which is only another way of saying that you lose definition, or rather contrast? If, therefore, you use discriminating rays, you must increase their penetration, not necessarily by decreasing their wave-length, but by increasing their amplitude, or, in other words, increasing their quantity. So little is known of the physical properties of these rays, that the solution of this problem is undoubtedly difficult at present. There is, however, one direction in which I think a solution may be found, and that is to have what is an equivalent to two or more tubes, and if you can get a tube with two or more cathodes playing on to exactly the same spot of the anode, you may be able to get the result you desire. I am trying to make a tube of this kind, but there are certain mechanical difficulties in the way of adjusting the cathodes that I have not as yet been able to overcome. It is possible to get more or less detail in softer parts of small animals, at all events, sufficient detail, I imagine, to be of great use to surgeons, or even to physicians, could the same detail be obtained in man; and what is possible with the smaller animals is, I feel confident, possible with man, could we only get sufficient power and tubes to stand that power, for I conclude that the relative density of bones to soft parts is approximately the same in both cases.

I should like to see a large tube made with a secondary bulb at the side, and exhausted as highly as possible with a mercury pump, and then have the mercury vapour frozen out with liquid oxygen in the way that Professor Dewar makes his vacuum jackets for liquid air, and then the bulb sealed off and a current from a large Wimshurst machine forced through.

I have made some negatives with a little ray meter made by Watson, as a test for some of the tubes I have been speaking about. All were subjected, as far as possible, to the same conditions, being exposed for thirty minutes at twelve inches from the tube, and all were developed together in the same dish. A piece of wire gauze was laid over the meter, as this enables the fainter holes to be more clearly seen, and it also shows whether the rays have penetrated the whole thickness of the aluminium, and is as well a test for definition.

No. 1 is an Allen and Hanbury's tube, not warmed. The resistance was a 4-inch gap; the bones of the hand showed faintly on the screen, being too transparent for a good effect, and a little hazy. The penetration was considerable, the rays having gone through the whole meter, and the contrast between the different holes is very fair, the last holes being rather faint.

No. 2 is the same tube warmed down to a 2-inch gap; no blue was visible; the tube was in better condition for the screen, the bones being sharply defined. The penetration was not nearly so great as in No. 1, only two holes showing on the negative.

No. 3 is the didymium tube not warmed, a 2-inch gap. It is not so penetrating as No. 1, but much more so than No. 2. The condition for the screen was very good.

No. 4 is the Hurst tube warmed, gap 6 to 7 inches. It was in brilliant condition for the screen, a piece of iron being easily visible through 18 inches of wood. The negative fully bears out what I have always found to be the case with this tube, viz., that the result is very flat. Seven holes only are visible, but the rays have gone through the whole meter; there is very little contrast between the holes.

No. 5 is a favourite old tube of mine, and was made for me eighteen months ago by Müller. It is of the same pattern as those recently made for Mr. Webster, and, except for its shape, it in no way differs from Müller's ordinary tubes. It is now very black, but this does not seem to interfere with its good qualities. The negative is as good as any; the rays have penetrated the whole thickness of the aluminium, and the gradation between the holes is good.

No. 6 is a "Penetrator," warmed behind the cathode to a 5-inch gap. The seventh hole is just visible and the penetration is good.

No. 7 is the American tube working at a 1-inch gap, the resistance was so slight that there was no alternative current over the KOH, which consequently was not warmed. For the screen it was very good indeed. The

negative is like No. 5, but, if anything, rather better. As this tube was working at a 1-inch gap, not warmed, it seems a contradiction to what I have previously said, viz., that a small resistance got by warming is better than the same resistance not warmed. The goodness of this tube may be accounted for from the fact that, though the vacuum is very high, the resistance is slight because the electrodes are large.

It is no easy matter to get a vacuum high enough for strong currents, so I would advise everyone if he has time to exhaust his own tubes. When I began this work I was using an ordinary Toepler pump, and, though some of the best tubes that are made are exhausted with this form of pump, it has certain drawbacks which make it difficult to obtain the best results. In the first place, air was always getting in through the indiarubber tube used for lifting the mercury, so I added an air-trap, but this was only a partial success, as the mercury still got fouled with the tube, and it is impossible to keep the mercury clean as long as the tube is adhered to. I therefore determined to get rid of the indiarubber tube altogether. This I did by forcing the mercury up by means of a bicycle pump, but it was difficult to work the pump slow enough to avoid blowing the head of the pump off. I then tried, what ought from the first to have been done, to allow the vacuum of the pump to raise the mercury, and then draw it down by another vacuum. In this I thought I had made a valuable discovery, when I was fortunate enough to come across the President's invaluable monograph on mercurial pumps, where I found my new idea was as old as the hills. Another defect in the ordinary model of pump is that the mercury, after leaving the fall tube, is exposed to the air, and thus becomes contaminated with dust and moisture, and has to be transferred to the lifting reservoir, where it is again exposed to the air. I have now confined the mercury entirely within the pump, and no air whatever gets to it without first passing over calcium chloride. A sketch will make the working of the pump clearer. With the assistance of the book I have mentioned, I think I have succeeded in removing nearly all theoretical difficulties of exhaustion. I have not had time to thoroughly test it, but, as far as I have done so, everything seems satisfactory. I am also much indebted to Captain Thompson, who has given me some valuable hints, having himself set up a pump on very similar lines to mine; but he has gone further, and his works automatically by attaching it to a filter-pump, whereas mine was worked from a Fleuss pump, which is certainly not so convenient, but it avoids all danger of the mercury coming in contact with aqueous vapour, and if there is a risk of this, it might no doubt be removed by inserting a desiccator between the two pumps. I have got rid of all stopcocks except one, and Captain Thompson has done away with this by using a mercury valve, but this involves the use of an indiarubber tube again, which I cannot but think will sooner or later let in air. If the stopcock is greased with a composition used at King's College, made, I believe, of boiled indiarubber, there seems to be very little chance of injurious results. The greatest difficulty to overcome is to get the mercury and the interior of the pump absolutely clean. It is impossible to lay too much stress on this. If everything is clean to start with, it remains so a long time with the arrangement I have adopted.

I am afraid I have not brought before you anything very new or original, but as a practical worker I have necessarily encountered certain difficulties, and my object has been to call attention to these, and to point out the direction in which I think they may be overcome, in the hope that others, better equipped with scientific knowledge and appliances, may find a solution to some of the problems that have baffled me.

A discussion followed; and a vote of thanks accorded to the readers of the papers.

MEASUREMENT AND LOCALIZATION WITH THE FLUORESCENT SCREEN ALONE.

By ERNEST E. PAYNE, Esq., M.I.E.E.

It will probably have occurred to almost every observer that objects might be localized by means of the screen alone, and thus save the time and trouble of taking a radiograph. The ease and certainty with which this can be done will depend upon the convenience with which the apparatus can be manipulated and adapted to each case as it arises.

It is, of course, not always possible to see the shadow of the object, and even when it is so the nature of the case and condition of the patient may be such that the tube cannot be placed on one side of the body or limb and the screen on the other.

Two observations must be made from different points of view, as with the radiographs. In the case of a needle or shot in the hand, successful localization ought

always to be possible; but where we have to deal with a bullet, for instance, in the chest or abdomen, where the wound has not healed and it is not thought desirable to disturb the patient, it might not be possible to make the needful observations, even if the bullet could be seen on the screen.

In some cases of this kind the patient can be placed on a couch of transparent material, with the tube below and the screen above him; arrangements of this kind are already in use. I use one composed of two silk rugs stretched loosely over a frame about 7 feet by 3 feet, on which the patient can recline comfortably as in a hammock.

For making a measurement both the screen and the tube should be fitted to adjustable supports, so that they can slide up and down, or from right to left, as required. If we wish to work from cross-lines, these can be shown upon the screen by means of two wires fixed across the

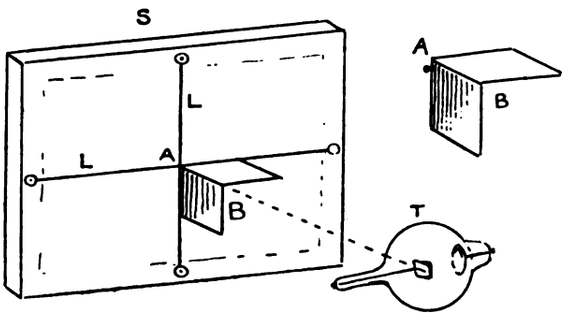


FIG. 1.

back at right angles. The tube is first adjusted so that the rays fall perpendicularly on the point of section of the lines. This position of the tube may be found by using a simple piece of metal about 3 inches long and 1 or 2 inches wide bent into a right angle, as shown in Fig. 1. It is held behind the screen so that the angle at A or at B coincides with the point where the lines cross; then, when the tube is vertically opposite this point in a line with AB, the shadow of the angle-piece will appear as a line equal to the thickness of the piece of metal of which it is composed.

To take a simple case, that of a shot in the hand. The patient holds his hand behind the screen so that the shadow of the shot falls on the point of intersection of the cross-lines. In some cases an adjustable rest to steady the hand will be found advantageous. We next make two observations, one with the tube shifted a given distance to the right, and another with the tube a given distance to the left of its original position, and note the movement of the shadow in each case.

Referring to Fig. 2, let SS be the surface of the screen; A, the first position of the tube, giving a shadow

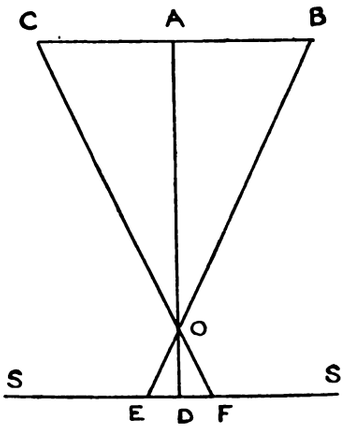


FIG. 2.

at D. Then, when the tube is at C there is a shadow at F, and when at B there is a shadow at E, O being the shot. Now, AD is known beforehand, as also AB and AC, and we measure DE and DF. The figure to show the distance of O from the screen may be prepared beforehand, full size. We fill in the points E and F as observed, and by drawing the lines BE, FC, obtain the position of O. If we employ threads and the apparatus recently devised by Mr. Mackenzie Davidson, we adjust the threads to represent the lines, and measure the distance of O from the table. A mark should also be made on the hand showing a point in a line with the shot when the tube is at A.

For any fixed values of AB, AC and AD, we can work out a table giving the distance DO in terms of the observations DE, DF, or EF.

Since the opposite angles at O are equal, we have by similar triangles,

$$\frac{DO}{DE} = \frac{AO}{AC} \text{ or } AB$$

$$\therefore DO \times AC = AO \times DE.$$

Now $AO = AD - DO$

$$\therefore DO \times AC = (AD - DO)\,DE.$$

$$\therefore DO \times AC + DO \times DE = AD \times DE$$

$$DO(AC + DE) = AD \times DE$$

$$DO = \frac{AD \times DE}{AC + DE}.$$

From this we can work out values of DO for different values of DE.

For supporting the tube an adjustable stand may be used like that shown in a previous article (p. 32), or any other convenient tube-holder. Fig. 3 shows a complete arrangement of screen and holder, which I have devised, which is simple and easily constructed. A board or table containing guides, as shown, is first

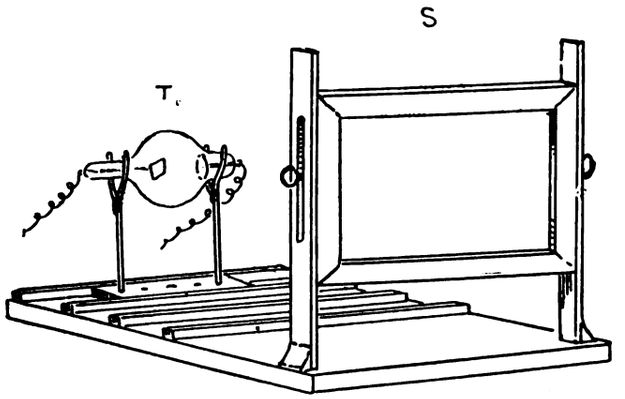


FIG. 3.

prepared; between these guides sliding bases holding the tube and the screen can easily be placed according to the distance required between the tube and the screen (AD in Fig. 2). In the figure the supports holding the screen are fixed.

These tube and screen holders can be readily removed and used for ordinary observations, and replaced on the table between the guides at any moment. Marks or stops must be arranged on the base of the tube-holder and along the guides for showing the distances through which the tube is moved.

The positions of the different shadows can be measured with compasses at the time, or adjustable sliding stops can be employed, sliding inside the frame of the screen, which can be adjusted to show where the shadow was, the distance between them being measured afterwards (this will give EF, Fig. 2).

If we require to make some measurement, such as the distance of a body from the surface, or some observation of an object such as a thoracic aneurism, and do not require to know its distance from the screen, we can employ parallel rays. Referring to Fig. 4, if we wish to know the distance between A and B, we first adjust the tube at T_1, which will give a shadow at S_1, and then move the tube to T_2, giving a shadow at S_2; but for this we must have a rod of opaque material that is rigidly fixed to the tube-holder so that both will move together, and arranged so that the tube will be on one side of the body and the rod on the other. A piece of apparatus for doing this is shown in Fig. 5. For making small

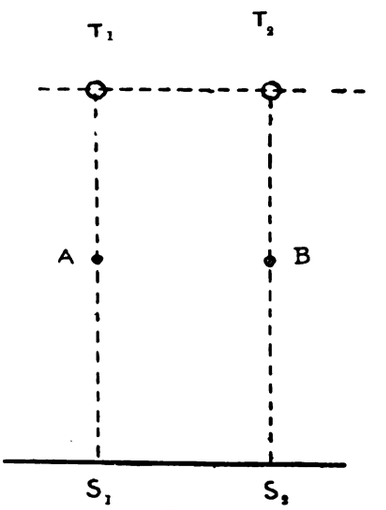


FIG. 4.

measurements it may be fitted to a stand that can be placed on the table, but for large work, where the patient's head or body must be placed between tube and screen, a support fixed to the wall or carried by two uprights on the floor must be employed.

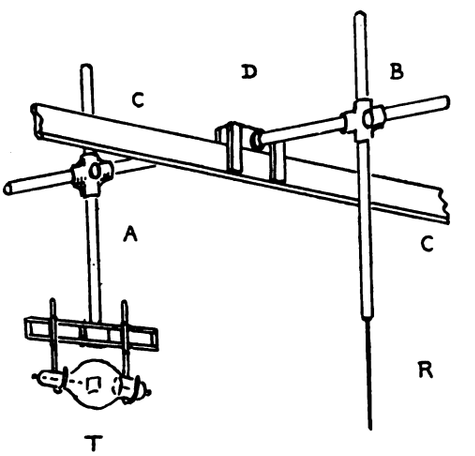


FIG. 5.

The tube T hangs at the end of a holder fitted with an adjustable socket at A, and a similar support is made for the rod R at the other end of the cross-piece at B; the latter slides through a block D, resting on, and moving along, a support CC, which, as above mentioned, may be fixed to the wall or to suitable standards according to

the size of the apparatus. The screen will then be held behind the rod R so that its shadow, together with that of the hidden object or part, will fall on the screen, the block D being moved along the beam CC until the shadows coincide. The movements of this block can be noted from marks made on CC. The screen may be fixed to the vertical arm B behind the rod R, in which case R may be merely a fine wire stretched across the screen, but it is more convenient to hold the screen in the hand and let the rod R be fixed at the end of the vertical support B.

In 1896 I devised a piece of apparatus for localization with the screen alone, which consisted of a circle or ring

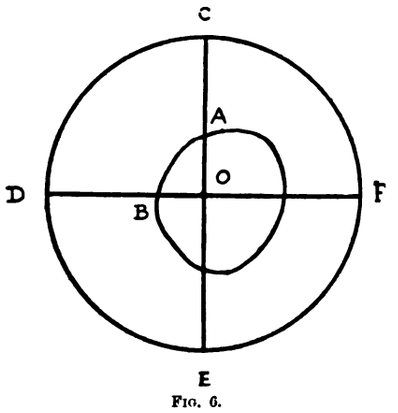


FIG. 6.

of rigid material, working on two sets of guides at right angles to each other so that it could be adjusted round the body or limb until the hidden object—a shot, for instance—was in the centre of the circle. Its position below the surface from any point round the circle could thus be obtained. Observations were made with a tube and screen at opposite ends of two diameters, preferably at right angles to one another. Referring to Fig. 6, if O is the hidden object, and CDEF the circle above mentioned, by means of a tube at C and screen at E we adjust the circle so that O lies along the diameter CE. Then again, with a tube at D and screen at F, we adjust the circle so that O lies along DF. O must now be at the centre, where the diameters CE and DF cut one another. The radius of the circle being known, the depth of O below the surface at any point, such as B, would be found by measuring DB, since OB = OD – DB. If, for instance, O were a shot in the arm or leg, its depth below the surface at any point desired could be found by measuring the distance of the surface at that point from the circle. The positions of the respective diameters were indicated by stops fixed to the circle on opposite sides, or, if the tube itself be rigidly fixed to the circle, only one stop is needed at the opposite end of the diameter.

For the purpose of localization an almost indefinite number of different forms of apparatus might be devised; their practical value, however, could only be tested by application to a number of cases. A convenient appliance for localization of needles only in the hand and foot ought to be of great use in a large hospital, and save much of the time and trouble involved in the use of plates.

Brighton, *March*, 1898.

A METHOD OF RADIOGRAPHY AND LOCALIZATION.

By HENRY WAGG.

THE apparatus which is here illustrated (patent applied for) is drawn from a radiography set supplied to the Evelina Hospital for children, Southwark, S.E., and is made of dimensions suitable only for children; but with slight alterations in dimensions and a few minor alterations in detail, it can be very easily adapted for adults.

A table A is constructed as shown in the drawing, having a top made of very thin wood, so as to allow the rays to pass through it; a shelf below the table-top carries the coil L, which is supplied by a current from battery M, which is placed below the coil on a small carrier mounted on castors, and so arranged that if you push the table about, the battery follows; but it can be readily removed for re-charging.

The tube is supported immediately below the table-top by a carrier, which works on slides aa, and it can be moved longitudinally, laterally, or vertically, and a scale attached to the slides aa shows how far it has been moved. An electric glow lamp H is kept burning below the tube, so as to reduce the vacuum. Hinged flaps are provided to the table, so that when in use it can be made as long as required, but nevertheless will, when closed, occupy very little space.

There is a framework B above the table which can be adjusted at various heights by means of the set-screws B 4. This framework is adapted to hold a photographic plate or fluorescent screen.

The patient is placed on the table and a fluorescent screen placed over him in the carrier adapted for it,

being dropped into a frame F which has two metal cross wires dissecting it, so that when the rays are turned on the wires show on the screen.

If it is required to localize a foreign body in the patient, the instrument shown at O, Fig. 2, is placed on the screen. The top of this instrument O3 is covered with some fluorescent material on which you will be able to see the shadow of the shot O2 fastened in the bottom of the instrument, and the shadow of the ring O5 fixed in the top of the instrument.

You move this instrument till the shadow of the shot and the shadow of the cross-wires coincide; then you slide the screen and cross-wires along until the shadow of the shot appears in the middle of the circle, with the shadow of the cross-wires intersecting them. Having done that, you remove the instrument O, and you know that the point of intersection of the cross-wires is vertically over the centre of the anode of the tube.

This, although it takes some time to describe, can be done easily in ten seconds.

Having got your tube vertically under the point of intersection of the cross-wires, you place the patient so that the foreign body, which you can see on the screen, comes immediately below the point of intersection of the cross-wires; you then move the tube some known distance, such as 2 inches, in either direction, and you will see that the shadow of the foreign body on the screen will have moved, say 1 inch, from the centre line.

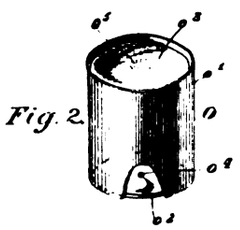


Fig. 2.

You then remove the screen and mark the point of intersection of the wires on the patient with a paint-brush. And having measured the distance of the screen from the table-top, and the distance of the tube from the lower side of the table-top, you proceed to use the chart shown in Fig. 3.

X represents the centre-line of the tube and screen, Y and Y1 the table-top, and P5 the fluorescent screen,

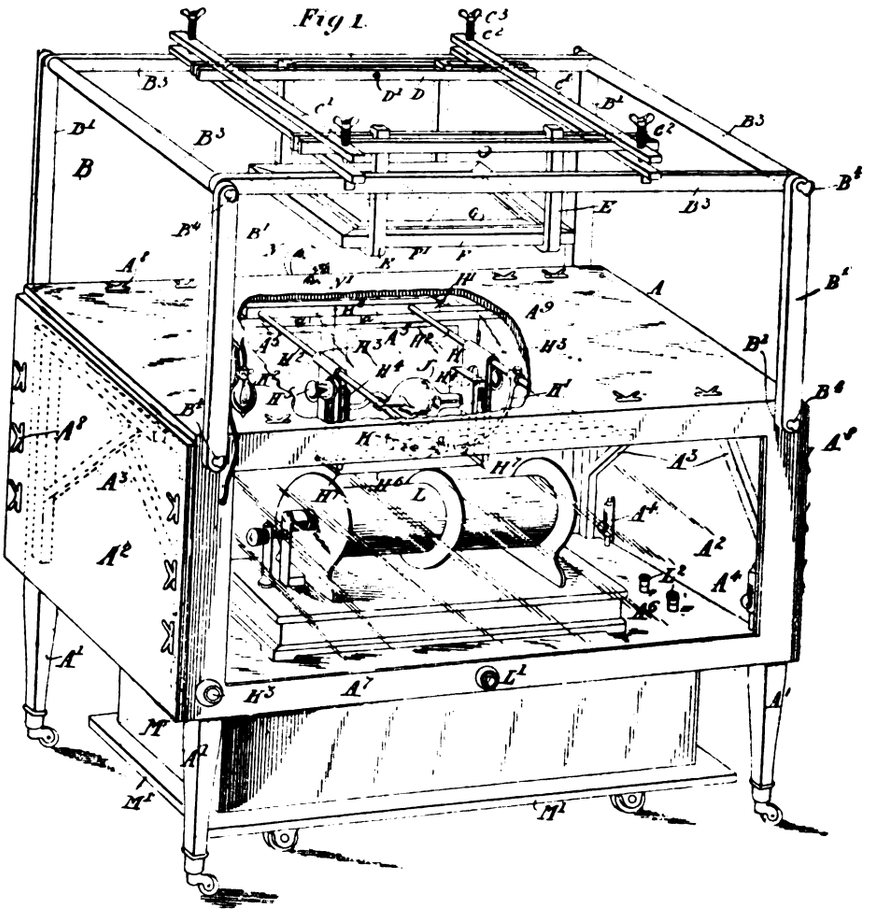


Fig 1.

this being a slide graduated in inches from both sides of the centre-line; P6 represents the tube, and is the same as P5, only fitted with a slit at each inch mark.

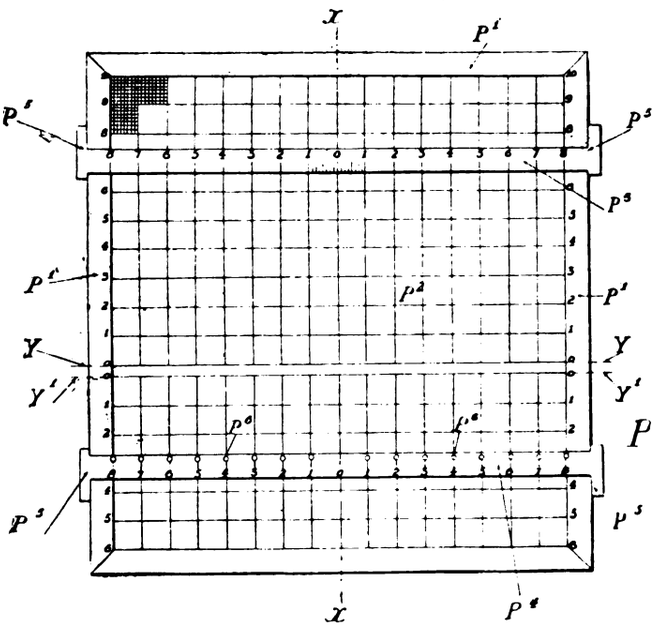
Having set the two slides in their respective positions, you pass a thread through the slit in the lower slide, which is 2 inches from the centre line, that being the distance the tube was moved; you pass the other end of the thread to the figure on the upper slide, which represents the distance on the screen of the shadow of the foreign body from the centre line. Where the thread crosses the centre line, which ought to be shown marked in inches in the drawing, there will be the exact distance of the foreign body from the table-top; or if the patient has been lying on his back, it will of course be the depth from the surface of his back, and the foreign body will

be immediately under the spot that has already been painted on him.

The whole process, from the time the patient is put on the table to the time you have worked out your results, can be done in two or three minutes easily.

If through any cause, such as the difficulty in handling the patient, you cannot get the foreign body right under the centre of the screen, then you take two shadow measurements on the screen, which are obtained by

Fig. 3



moving the tube a certain distance one side of the centre line, and then moving it the same distance the other side, and measuring the distance of the shadows from both cross-lines; you then remove the screen and paint the cross-wires on the patient instead of only the intersecting point.

You now take the chart, which you use in the same manner as before, only with two threads instead of one, one representing each position of the tube. Where the two threads cross will be the height of the foreign body from the table-top and the distance from one of the cross-lines; then you deal in the same manner with the measurements you obtained from the other cross-line on the screen, and you get the exact position and depth of the foreign body. This latter method is similar to that devised, I believe, by Dr. Mackenzie Davidson, only working with this new method of measurement makes it possible to work very much quicker and more accurately than formerly.

The apparatus, being light and very compact, can be wheeled from one part of the hospital to another with ease, or can be carried by two men up and down stairs.

If it is required to apply the rays to a patient in bed, a couple of long glass tubes are provided, which are fitted with a terminal at each end and a wire inside; these are passed through two rings in the side of the table, and are connected to the terminals of the coil inside; the rods stand out like the jib of a crane, and on the top end a tube can be hung at the desired height above the patient.

In all the above methods a photographic plate can be used if desired instead of a screen.

A very simple method is also provided for obtaining the exact distance of the tube anode from the table-top.

An instrument like that shown in Fig. 2 is used, only made on a slightly larger scale, and rectangular instead of round. A fine wire is fixed in the bottom of the box at a certain specified distance from the shot, a scale is fixed on the fluorescent top; after aligning the shot and circle as previously described, you see where the shadow of the wire falls; this will be at some point along the scale, which is marked so as to indicate in inches the distance of the tube from the bottom of the box, or, in other words, from the table or screen on which it is standing.

Great George Street,
Westminster, S.W.

THE ROENTGEN SOCIETY.

A GENERAL MEETING of the Roentgen Society was held at 11, Chandos Street, on Tuesday, April 5th, 1898, at 8 p.m. Prof. SILVANUS P. THOMPSON, F.R.S., in the chair.

The PRESIDENT announced with great regret that the hon. secretary, Dr. Walsh, was absent through ill-health, and that Mr. J. J. Vezey, a member of Council, had kindly undertaken his duties for the evening.

The minutes of last general meeting were read and confirmed.

The following were balloted for and declared duly elected: H. W. Cox, H. J. Loe, J. H. Dudgeon, Miss Roma Austen, Miss Moberley, A. P. Sinnett, Dr. Heber Robarts.

The following candidates were nominated, on the re-

commendation of the Council, for ballot at next meeting: Leon. Gaster; Arthur Talbot; Walter D. Jamieson; John Lynn Thomas; T. Maltby Clague; W. Reginald Cookson; Frank S. Pepperdene, M.A., Ph. D.; Margaret Mary Sharpe, L.R.C.P., L.R.C.S. Edin.; Leslie Miller, A.I.E.E.; Harold H. Simmons, A.I.E.E.; Ernest Greville, M.B., C.M. Edin.; F. H. Buhl; Sydney F. Walker; Lewis Jones, M.D.; Alfred Apps, M.I.E.E.

Exhibits:

1. A drawing by Mr. Webster, and a note supplementary to his paper read in January last.

2. Two photographs from Mr. W. A. Coldwell, one a case of hip disease, the other a case of prostatic calculi.

The PRESIDENT announced that, in accordance with the suggestion made at the last general meeting by Mr. E. Payne, the Council had just appointed a committee for the investigation of dermatitis (X ray).

The next meeting was announced for May 10th.

A paper was then read by Mr. James Wimshurst on "The Advantages of the Influence Machine for Lighting X Ray Tubes," with a demonstration. The following is a verbatim report:

My paper refers to the advantages of the influence machine for lighting the X ray tubes.

To make it clear that there is reason for introducing the subject, it is better perhaps to call to your mind the more prominent troubles and difficulties which you may have met with when using the coil for exciting the tubes.

In the first place, the coil has to be supplemented by a battery; the battery requires frequent charging; the leakage is an item; the battery must be kept fairly well charged, otherwise the plates quickly lose their efficiency, or go altogether wrong. The battery may be needed for a long exposure, and then be found to contain less than the necessary charge. The continual sending and fetching from the charging station entails trouble and expense.

The contact breaker of the coil is another source of trouble; the platinum contacts waste, they require frequent adjustment or renewal. When working it is a noisy appendage.

When the coil is working at its best there is danger of it heating, and the insulation being pierced.

I will not name the smaller troubles; but, suppose the coil to be working at its best, you then find the tube is lighted in a flickering manner, which is caused by the sparks being intermittent, the interval of light being a small fraction of the time, and the interval of darkness being the larger fraction of time. This flicker becomes painfully evident when a long use of the screen is needed; it is probably harmful to the eyes of the operator.

I am afraid it may be thought that I am raising an unpleasant picture to the prejudice of an interesting instrument. These troubles were, however, in my mind when your hon. secretary kindly asked me to contribute a paper, and it seemed to me that the most useful subject to bring forward would be the question whether some better means for exciting the tubes is not present amongst us. I hope to make it clear that there is a simpler and better means.

Your President in his inaugural address referred to the influence machine as an exciter for the tubes. It is the influence machine and its capabilities that I wish to call your attention to this evening. The characteristics of these machines are such that they may stand from day to day, or from year to year, without trouble or without concern, yet, whenever the handle is turned, the machine gives out a large and continuous flow of electricity; and this may be relied on, whether it be wanted for an hour or for the whole year through, for there is nothing in them but metal, wood and glass, and they are about as durable as clocks.

I now show the simplicity of construction by these two glass discs. They are varnished on both sides, and tinfoil sectors are placed upon the face side of each of them; the discs are then attached to the bosses, which are free to rotate on a spindle. Small brushes of fine wire are arranged to lightly touch the tinfoil sectors, and, as you see, a single turn of the discs produces excitement.

Some ten or more years ago I exhibited at several leading institutions instruments of this kind, and also others in which the glasses had no sectors upon them, but I found glasses without sectors were troublesome, and that when viewed from all points they were not so satisfactory.

The larger machines, which are on the table, each contain twelve discs; they are furnished with what is found to be the most useful number and size sectors; they have, besides, the collecting combs and the usual terminals for the purpose of supplying a current of electricity for outside purposes.

For hospital use and for the battle-field work the glass may very well be replaced by vulcanite; it is, however, a material which is apt to warp, and also to change

in its insulating qualities, but these disadvantages are small in comparison with the charging of the batteries and the difficulties which are connected with any other form of excitement.

Since the X rays were discovered by Professors Lenard and Roentgen, improvements have been made in the tubes by Messrs. Jackson and Swinton; many others have also done much useful work. This work may be viewed under two chief heads, viz., the fluorescent screen work, and the photographic work. The fluorescent screen work depends upon the quality of the tube, the efficiency of the supply of electricity, and upon the quality of the screen in use.

Unfortunately we have no standard in this matter, and the goodness of the picture upon the screen is judged by personal observation, each person having his own standard of efficiency.

The only comparative test which I have seen is the use of a card which has metal numbers upon it, each increasing number being made more and more obscure by additional covers of tinfoil. The clearness with which the higher numbers may be read constitutes a graduated measure of efficiency of the whole of the appliances combined.

Photographic tests are perhaps better for comparison, provided the same tube, the same sensitive plate, and the same exposure be given; for it is quite necessary when making tests that all the conditions should be the same, excepting only the one feature which may be under trial. For instance, when the source of excitement is in question, then the only change which should be made is that the influence machine should take the place of the coil.

Through the kindness of one of your Council I have a negative which carries test pictures, the card of numbers before named being used. Two of the pictures were taken by means of the coil, the exposures being thirty seconds for the one and sixty seconds for the other. The other two pictures were taken by use of an influence machine, like exposures being given. You will see by the paper print that the influence machine has done more, or better work; the print is best viewed as a transparency.

It may now be asked, What sized influence machine is necessary for doing good work? I should hesitate to say, unless the work to be done is first known. The structure of the bones of the hand may be photographed by using a machine with one pair of 20-inch plates and an exposure of four minutes. With the smaller of these machines I have taken very good pictures of the hand with one and a quarter minutes' exposure. I may say that I have always used the rapid Ilford plates and Hydroquinone developer.

It seems to me that the good lighting of the tube depends greatly upon the quantity of electricity which passes through the tube; hence, as the output of electricity from a machine is about directly in relation to the revolutions of the glasses, the quicker the machine is turned, the more efficient is the lighting. It is, however, better to have a machine of sufficient size rather than to tax everything beyond the normal. These pictures were each taken with an exposure of one and a quarter minutes, the glasses rotating at moderate speed.

When comparing the light given by the two sources of supply, it should be remembered that the sparks from the coil are intermittent, the interval between the sparks being much longer than their duration; hence their photographic value in relation to time of exposure is less than might be expected from observation.

On the contrary, with the influence machine the charge apparently passes through the tube in a continuous flow, which gives a more constant illumination and a more effective action upon the photographic plate than will be supposed from observation.

It is, however, always better to possess a little excess of electrical power, for the larger supply means nothing beyond a small increase in the first cost of the apparatus.

Attention should always be paid to properly connecting the tubes to the machines, for if the covered wires be left with their ends exposed, or a leak be left unattended, it is well-nigh fatal to good results. This may be seen by placing a fragment of wire upon each of the terminals, and leaving the ends of the wires exposed; the wastage of electricity is then so great that the sparking length is reduced to about 1 inch.

The better way to connect the tube is to fit the ends of the wires into the holes in the terminals, and to fit the other ends of the wires into the holes made in the tube-holder to receive them. This newly-designed tube-holder also embraces the ends of the tube, and is the more efficient because when at work there are no leaks at any part of the whole circuit. You now see the tube in place and fully lighted. When you do not possess a suitable tube-holder, it becomes necessary to cover the

ends of the wires by metal balls, and to bring these balls into contact with the ends of the tube. It is sometimes found better to leave small spark gaps between the balls and the ends of the tube, or to leave a spark gap inside the wooden attachments which fit on the terminals of the machine. The choice of system of connection may readily be determined by experiment. You now see the efficiency of the appliances by means of the screen.

In cases where the machine is small relatively to the resistance of the tube, it may be found better to connect the ends of the tube to the outside coatings of Leyden jars, and to set the terminals of the machine at a suitable distance apart, so as to pass small sparks. Whenever practicable to use the direct flow, it is better to do so.

Having now spoken a few words relative to the method of exciting the tubes, I may perhaps be permitted to give a further few words upon the construction or preparation of the tubes, and matters connected with them.

The tubes are of glass, of special quality; the terminals within them are made of platinum and aluminium; the atmosphere is withdrawn from them.

The gases which were occluded by the surfaces of the glass and the metal have been repelled by heat, and the greater part of them withdrawn.

The few molecules, or particles of gas, which may remain within the tubes must be very greatly expanded in size. We can only suppose them to be so greatly expanded as to still be in contact with each other, and also with every surface within the boundary of walls of the tube; but, of course, at about zero of pressure.

If we accept the hypothesis of an all-present ether, the ether within the tube remains unchanged.

It is difficult to freely accept the view that two things can occupy the same space; yet I think the attributes of ether are such that we have to assume it is undisturbed by either the absence or the presence of atmosphere.

If this be so, then the only new condition within the tube is that the vapour of mercury has entered it.

With regard to the excitement, it is known that electricity passes with difficulty through an atmosphere which is compressed; that it passes more freely through air at the atmospheric pressure; that it passes still more easily when the air is partly exhausted. As the exhaustion approaches completion, the apple-green colour appears in the tube, and also the X rays commence. Is this latter change brought about by the comparative absence of air and the presence of mercury vapour?

After still further pumping and heating, the exhaustion of the tube is deemed to be satisfactory; the tube is sealed off. Nothing afterwards enters; nothing leaves the tube. Still, all the changes are not completed, for after much use it is found that the resistance to the passage of electricity increases, and with this increase in resistance the penetration of the X rays advances.

While this change is going on, it will be noticed that the tube becomes discoloured. May we not usefully seek to learn the causes of these changes?

It would seem that ether takes a small (if any) part in the transmission of electricity, and that the path is furnished by either the attenuated atmosphere or by the mercury vapour.

Then, is the attenuated air, which is still within the tube, again absorbed by the glass or by the metal? Then the cause of the discoloration of the tube by use? Is this discoloration due to some part of the mercury vapour decomposing upon the surface of the glass? This is quite probable, because, when by use the tube becomes discoloured, its resistance increases very much, and then by heating the tube the resistance falls considerably. May it not be that the heat applied again sets the mercury vapour, or a part of it, free?

That mercury vapour plays an important part in the X rays is strongly supported by the experience of some tube-makers, for they hold that when brass, solder, and other metals are used, it is not possible to get a good enough vacuum to emit the X rays. They suppose these metals give off gas, and continue to do so. The probability is that the mercury vapour enters the tube and amalgamates with the metal. Then, as there is no free mercury vapour, there are no X rays.

We assume that ordinary light is a vibration of some kind, in a medium; this light affects our eyes, but it does not penetrate every substance.

The X ray does not affect our eyes in the same manner as the visible position of ordinary light. May this difference not be a different rate of vibration in a different medium, the new medium being vapour of mercury, and the new rate of vibration being due to the different density of the vapour?

It is accepted by some that the heating of the anode and the emission of the X rays are produced by a bombardment of molecules, shot off from the cathode;

but if we reason from experiment, it is difficult to accept this conclusion. You will accept the fact that bodies, when equally electrified, repel one another, and also that bodies which are unequally electrified attract one another. From this we can only suppose that any molecule which receives a positive charge from the anode will seek another molecule which has received an opposite charge from the cathode, and in this way the several charges would be passed from the anode to the cathode. This action is shown by these celluloid balls, held between the metal plates, which are upon the terminals of the machine. This rapid transference of charges from molecule to molecule may, and probably does, start and maintain the particular X ray vibration.

Here is a Crookes' tube, in which is a little wheel with vanes; between the wheel and the terminal of the tube is a baffle plate. When the electricity from a coil is passed through the tube, and the flow is deflected by the application of a magnet, the wheel turns round either to the right or to the left, according to the position of the magnet. I am not, however, able to show this rotation with current from an influence machine, because the magnet does not deflect the current sufficiently. However, you may see a like rotation of this large wheel, and also the rotation of these paper fans: when they are placed between the terminals of the machine in the open air they rotate rapidly, but their rotation is, as you see, from the anode to the cathode. Again, when this sheet of paper, or this sheet of mica, is placed between the terminals, they also travel from the anode or positive pole to the cathode or negative pole. The only deduction which can be reached from these experiments is, that the motion of the wheel, the fans, the paper, and the mica, is caused by the material accepting a positive charge of electricity when near the positive pole, and then it seeks to deliver that charge to, or near, the negative pole. In other words, the motion is produced by simple electrification.

If it were possible to take out a single molecule, then to stain and replace it, it is quite probable we should find it remain, relatively to other molecules, without much change in position, and that such altered position as might be taken would be in, and with, the electrical flow—viz., from the anode to the cathode.

Further, the X ray appearing to start from the anode is probably owing to the forms given to the metal terminals within the tube, in combination with the direction of the current. Bearing on this feature, I have here a tube in which are the ordinary ball-faced terminals. This arrangement gives the X rays from all parts, no matter which way the current passes through it; being so generally lighted, the light at no place is good, nor does it make sharp pictures.

I have also had made another form of tube, in which the cathode is formed as usual; but from the bulb is a long tube, the end of which is continued by indiarubber, through which any form of anode may be passed. The whole tube is then filled with mercury and inverted. Repeating this several times, and applying heat, a good exhaustion may be obtained; but as yet I have not had sufficient time to carry the experiment to success.

There are still two other forms of tube I should wish to see made; they may both be of the ordinary form, only that one of them should have an open reservoir, containing free mercury. The second tube should have a similar reservoir, containing tin or other metal which freely amalgamates with mercury. The first tube would show the behaviour of a space saturated with mercury vapour. The second tube will show the behaviour of the space without mercury vapour.

One other feature seems to me to be worth notice: it is the heating, or may I say the colour, which appears at the anode. When the tube is working it may not be generally known that the electricity necessary to heat, or to colour, all the large piece of metal may be passed through a wire of less size than human hair; yet this small-sized wire may be held by the fingers without the sensation of heat.

The explanation seems to be that the resistance of the whole circuit displays itself at, or upon, the surface of the anode plate, and the transference of energy to heat takes place at this surface only.

Mr. SWINTON regretted he had heard only part of the paper. He did not agree with Mr. Wimshurst's views as to the fall of potential. He believed it took place chiefly near the cathode, not at the anode. This had been confirmed among others by Sir W. Crookes, and was mentioned by him in his presidential address to the Institute of Electrical Engineers. With reference to Mr. Wimshurst's experiment with paper vanes, he did not think any analogy could be drawn between the conduct of the vanes in air and the same in a vacuum tube. He thought that in testing the relative advantages of induction coils and influence machines it would not be right to use the same tubes, because his experience had led him to the conclusion that a tube which worked well with a coil

might work badly with an influence machine, and *vice-versâ*. He recommended that the tube which worked best with each respective machine should be used in making a test. He agreed with Mr. Wimshurst that a tube lighted by an influence machine gave a very steady illumination on the screen.

Mr. ISENTHAL did not think a fair comparison could be made if different tubes were used on the two kinds of machines. In his view, the length of spark from each must be equal before a fair test could be made. While he had seen some very good photographic work from the influence machine, he thought that its size would be a serious drawback to its use. A large machine could not be said to be so portable as a coil.

Dr. LEWIS JONES thought that each machine had its special sphere of use. He had done some very good work indeed with influence machines. He had found that a machine with four pairs 18-inch plates, run at 180 revolutions per minute, would give as favourable work as that done with a 6-inch induction coil; in fact, one of the best photos of the forearm he had ever seen had been taken by his four pairs 18-inch Wimshurst with four minutes' exposure. In his experience, high-resistance tubes suited the influence machine best. He thought that machine would be found of considerable advantage in the country, where it was not easy to get accumulators charged for working induction coils.

Dr. MACINTYRE said that most of his work had been done with induction coils, though he had recently been enabled to make experiments with a large influence machine of Mr. Wimshurst's, consisting of twenty-four plates of 36-inch diameter. He had also done work with the machine belonging to Lord Blythswood, which consisted of 160 plates 36-inch diameter. He had also worked with the same machine reduced to forty plates, and he thought he got better views of the deep-seated structures, bones of the skull, thoracic and pelvic regions, than he had with the coil. He suggested that in order to get a fair comparison of the two kinds of machines, they should each be tried on the same part of the body—and he suggested it should be a deep-seated structure—with the tubes best adapted to them. He thought that each machine had its place, and neither would displace the other. He believed the coil would be found most suitable for hospital work. He had recently had a new mechanical break fitted to his 18-inch coil by Mr. Apps, and with this he had obtained some remarkable results. He had been able to obtain fluorescence on a screen held 40 feet from the tube, and had taken a radiogram of a chest-wall with 10 seconds' exposure.

Mr. PAYNE gave his experiences with a penetrator tube worked by a large Wimshurst. He had found it better than with an 18-inch coil. He suggested that photographic tests as well as screen tests should be used to determine the value of each machine. He had a large bulb-tube which did not give very satisfactory results on the screen, but was excellent for photography. He agreed with the previous speakers who had remarked on the steadiness of the lighting by means of the influence machine.

Mr. GARDINER commented on Mr. Wimshurst's suggestion that the mercury vapour remaining in the tube has a great deal to do with its efficiency. Mr. Gardiner had succeeded with great difficulty in getting some tubes quite free from mercury vapour—at least, its presence could not be detected by the spectroscope—and he had found that they gave very good X rays, which seemed to show that the presence of mercury vapour was not a necessity.

Mr. MOORE detailed his experience with a small Wimshurst, and had got fair results. He handed round some photos taken with three minutes', eight minutes', and sixteen minutes' exposures on the same subject. At three minutes he found the coil best. At eight minutes he found coil and influence machine about alike. At sixteen minutes he preferred the photos taken with coil. In his experience he found each machine required a different tube. What was good for one was not necessarily good for the other.

Mr. WILSON NOBLE observed that Mr. Wimshurst had not used condensers or Leyden jars in his experiments to illustrate his paper, and he asked whether they would not be of assistance in working with a refractory tube.

The PRESIDENT asked Mr. Wimshurst a series of questions: (1) What was his experience of his machines without sectors on the plates as compared with those with sectors? He suggested that as a larger number of sectors gave a more continuous spark than a small number, plates entirely without sectors might give a more continuous spark still. (2) Was the quantity of output of electricity proportional to the number of plates used? *e.g.*, would a machine of four plates, driven at 180 revolutions, give the same result as a machine of eight plates, same diameter, driven at ninety revolutions? (3) Had Mr. Wimshurst had any experience of dermatitis in working with influence machines? The President

did not agree with using the same tube on both machines unless the spark given from each was of the same length. In his experience he had observed that there was not the same heating of the anticathode with the influence machine as with the coil.

Mr. WIMSHURST replied. As to the President's question, he regarded the sectors as reservoirs, and did not think they affected the continuity if the space between them is made small, but he had found that in machines without sectors there was a much greater difficulty of self-excitement; more brushes were also required. He had driven plates up to 6,000 revolutions per minute, with proportional increase of output of electricity. He thought there might be a little longer spark without sectors. He did not think the Leyden jars would be of great service, as he thought that a tube was lighted by the quantity of electricity, and not so much by intensity. He had not heard of any case of injury from using an influence machine. He thanked the members for the kind reception they had given his paper.

A cordial vote of thanks was passed to Mr. Wimshurst.

A THEORY IN REFERENCE TO THE ORIGIN AND CHARACTER OF X RAYS.

By GEORGE ADAM, M.D.,

LECTURER ON ELECTRO-THERAPEUTICS, COLLEGE OF PHYSICIANS AND SURGEONS, SAN FRANCISCO.

JEAN PERRIN ennunciated the following theory in reference to cathode rays: That, there being an intense electric field in the vicinity of the cathode, some of the molecules of residual gas are torn into ions. The negative ions start towards the positive pole, but, gaining sufficient velocity, they go outward in straight lines independent of the anode. The positive ions move towards the cathode. Accepting this hypothesis, the writer would extend the theory in explanation of X ray phenomena. Supposing we have a residual gas such as carbonic acid (CO_2). Disintegration takes place at the cathode, the carbon seeking the cathode, the oxygen starting for the positive, but acquiring an enormous velocity which is capable of overcoming the attraction of the anode, if that pole is not directly in its path.

The oxygen ions are electrified by the current.

The forces, therefore, that are active in this stream of oxygen which form the cathode rays are as follows:

A large kinetic potential, an electric charge, an atomic attraction or adhesive force, and an atomic separative force, owing to the high exhaustion of the tube and increase of intermolecular space. To what extent do these forces act together, and to what extent do they oppose each other? I would reason that the electric charge would strengthen the atomic adhesion, and thus keep the atoms in a molecular state, whereas the velocity and the rarity of the gas would act in the opposite direction to separate the atoms and break up the molecule.

The characteristics of the cathode rays prove that the molecular condition is maintained. The chemical action, therefore, that would take place at the cathode is represented thus:

$$(CO_2)_2 = C_2 + (O_2)_2,$$

and the cathode rays would be represented by the formula

$$O_2 + O_2.$$

It will be well here to consider the relationship of an electric charge to atomic adhesion. An electric current passing through a solution of a substance whose atomic constituents have different polarity will produce molecular disintegration; but there is no evidence, however strong the current, that atoms of the same polarity would be separated. On the contrary, atomic adhesion is a form of magnetism, which latter obeys the same laws as electrification and may be identical. Or it may be stated thus: That it requires positive and negative electricity to produce molecular disintegration in the electrolyte. In this instance the oxygen molecules are acted on by the negative electricity of the current.

The cathode rays bombard the fluorescent spot as molecules.

What do the cathode rays lose at the bombarded spot? They lose their electric charge. This is proved by the difference of the action of X and cathode rays in charging and discharging bodies. Do they lose any of the velocity? No; because there must be a reverse stream from the bombarded spot to establish an equilibrium in the exhaustion of the tube. This reverse force acts only at the commencement with the X ray stream.

Then, what forces are active in this stream of radiant energy as it leaves the bombarded spot? The kinetic force, the separative force, owing to the increased intermolecular spaces, and the atomic adhesive force (assuming that this last is a magnetic force, some of it may also have been lost in the bombardment).

We have, then, two disintegrating influences capable of overcoming the one adhesive force, and as a result the molecule is torn to pieces. Issuing then from the bombarded spot is a stream of atoms, in this case of oxygen, with an immense kinetic potential and intense chemical potential. The formula would be

$$O+O+O+O.$$

The stream is sent out in straight lines from the bombarded spot, the same as the cathode rays issue from the cathode.

Let us consider some of the characteristics of the X rays, and see if they can be accounted for by our atomic theory. The penetrating power of atoms must necessarily be greater than that of molecules, and in this respect comparison with other radiant energies supports our theory. The penetrating power would be different in different media owing to the chemical action, and as the stream would decrease in velocity the chemical action would assert itself.

Would not the bad effects produced by long exposure to X rays be accounted for by the chemical action of the atoms on the tissues?

Having lost its electric charge and perhaps some of its magnetic adhesive force, such a stream of atoms would not be expected to be influenced by a magnet, but being infra-normal in this respect, when passing through a body would draw magnetism from the body, even if the latter was in a state of zero. This would account for the rays being influenced by the magnet after passing through a silver leaf.

A similar explanation will apply to the X rays being incapable of charging a body electrically, and of its power to discharge a body already charged.

The X rays are not generated in Geisler tubes because the intermolecular spaces are not large enough to assist in the work of disintegration of the molecule, and we have in that case a molecular stream.

In reference to Righi's experiment, showing that bodies in the neutral state were positively electrified by X rays, I would offer this explanation:

The X rays take away negative electricity from such a body and leave the latter positively electrified by the body's own electricity.

Thompson's experiment, showing that the penetrating powers of X rays varies with the vacuum, that is, the higher the vacuum within certain limits, the greater the penetrating power, may be explained in this way: The enlargement of the intermolecular spaces is followed by a greater inter-atomic space in the stream. As the rays meet resistance the space between the atoms becomes smaller, and when the space is entirely obliterated the atoms unite and form molecules. It follows that the larger the space, the longer the time it will take to obliterate it, and therefore the greater the distance travelled. This explanation would also account for there seeming to be two or more kinds of rays differing in penetrating power.

Such a ray as described, which we might call the atomic ray, would not be expected to be found in sun light, nor any artificial light known, and the X ray is not so found.

Radiant energy, consisting of a stream of atoms, would be a real ray, and would not be characterized by refraction, diffraction, or interference phenomena, such as wave motion is, and no such characteristics have been found in X rays.

A stream of molecules, or particles, would not be expected to produce all the phenomena characteristic of a stream of atoms, and accordingly we find no real ray obeying the same laws as the Roentgen ray.

LOCALIZATION AND MEASUREMENT OF HIDDEN BODIES BY THE AID OF ROENTGEN RAYS.

By ERNEST PAYNE, M.A.

(*Continued from page* 32.)*

In February, 1897, I made some radiographs from the pelvis of a skeleton with a view to determine how far the method above described might be employed for making pelvic measurements, and described the results at the April meeting of the Medical Society of Brighton. Two of these radiographs were made with the object of obtaining the antero-posterior diameter, from the sacro-vertebral angle to the symphysis pubis. One was taken with the tube vertically above the symphisis; in the other the tube was above a point which would correspond with the umbilicus. The shadow of the symphysis pubis is clearly defined in both radiographs; the exact line of the angle of the sacrum is not, however, so sharply given in the reduced copies. In actual practice this is the most difficult part to take clearly. Fig. 4 shows the first-mentioned radiograph and Fig. 5 the other, while Figs. 6 and 7 are photographs of the same pelvis

* Publication unavoidably prevented in last issue, February, 1898.

taken from similar points of view; it is interesting to compare these with the radiographs.

By superposing the two figures and projecting lines from the edges of the shadows to points corresponding with the anodes of the tubes, we obtain a graphic diagram shown in Fig. 8. E F represents the diameter of the shadow given when the tube is at S, while C D represents the diameter of the shadow given when the tube is at T (above the umbilicus). By drawing lines from the point T to the points C and D, and from S to E and F, we obtain the size and position of A B, which will correspond with the antero-posterior diameter required; A showing the position of the sacro-vertebral angle, B that of the os pubis.

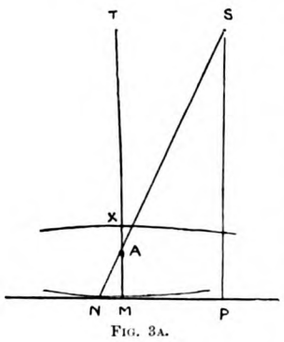


FIG. 3A.

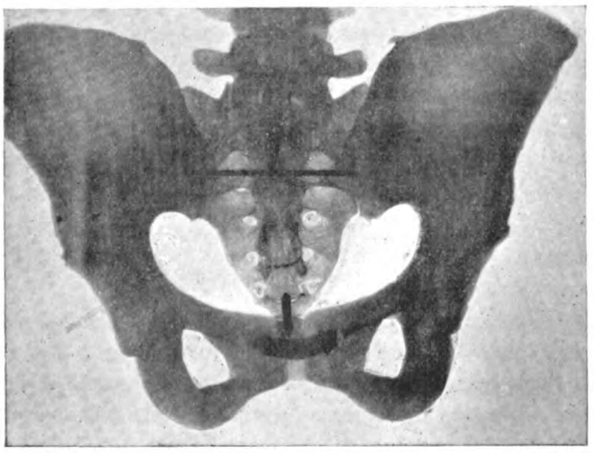


FIG. 4.

When taking the radiographs it is necessary to note, as accurately as possible, the position of the body with regard to the plate, and it would be advantageous in most cases to mark the plate itself.

If no mark is made on the plate, the position of the edge of the plate must be measured with regard to some point, such as the umbilicus or ilium, or some mark made on the skin at the time. The plate may be marked by placing some small piece of metal upon it, which will give a shadow, the marks being made in each case in the same position with regard to the body. The positions of the tubes with regard to the plate are also measured. Some form of sliding rule may be employed

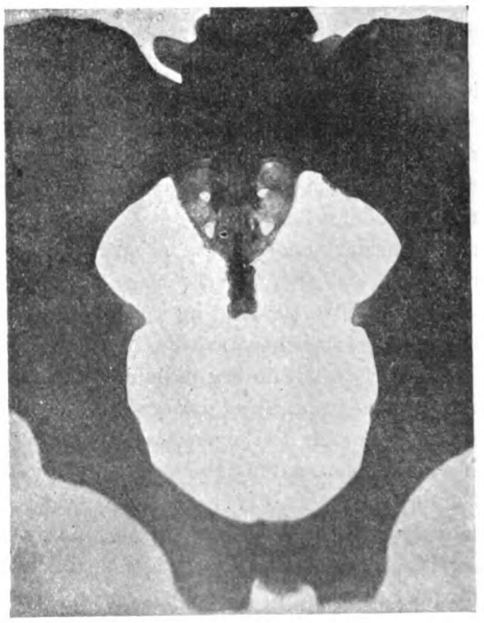


FIG. 5.

for this purpose, similar to the one described and illustrated in Fig. 2.

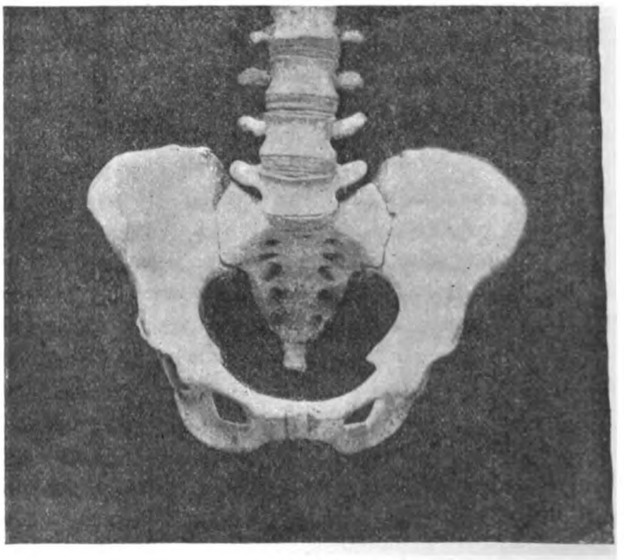


FIG. 6.

Hitherto, good radiographs of the pelvis from the living subject have only been obtained in exceptional cases. It is, however, to be expected that with the

latest improvements in the apparatus better results will be obtained and with more certainty. Dr. Max Levy recently obtained radiographs of the adult pelvis in three or four minutes by employing intensifying screens in

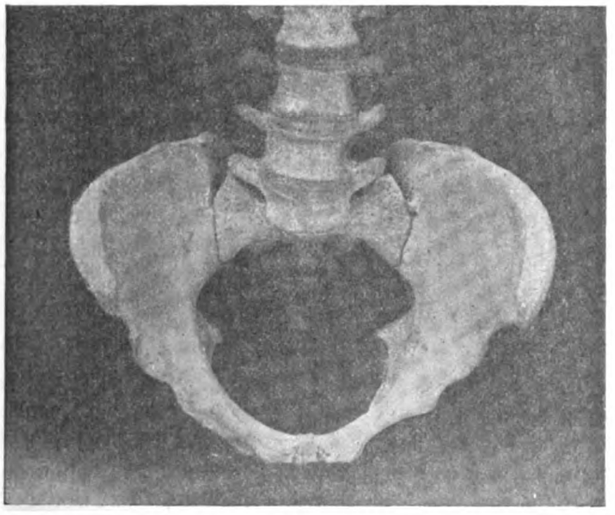


Fig. 7.

combination with his new Roentgen plates, sensitized on both sides.

If the position of an object is only imperfectly known and cannot be seen previously on the screen—as might be the case of a needle or shot in the thigh, for instance—it will be found that the object does not lie in the vertical plane below the tube. Referring to Fig. 3A (p. 90), which may be regarded as an end view of Fig. 1 (p. 31), the hidden object A may be in a plane at an angle to the plate, as S N instead of S P. To find the distance below a point exactly above A, we must draw a perpendicular

Fig. 8.

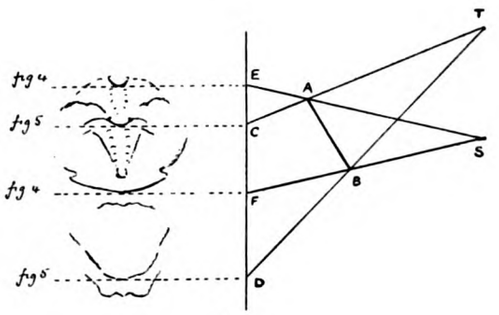


Fig. 8.

T M through A, which gives a point X on the surface, from which the distance A X will be measured. The position of X would also be measured from the marks or stained lines above referred to, made by the covered wire or small pieces of metal, if measurements could not be made from the edges of the object. In dealing with the hand or fingers, measurements can be made from the edges; but where the thigh or the body is concerned, measurements must be made from artificial spots or lines. The artificial marks should be made on the surface in the plane S P if possible.

Brighton, *September*, 1897.

Notices of Books.

Practical Radiography. A handbook of the applications of the X rays, with many illustrations. By A. W. Isenthal and H. Snowdon Ward. Second Edition. Published for the Photogram, Limited, by Dawbarn and Ward, Limited, London.

An attractive-looking volume and a trustworthy exponent of the radiographic art. Eminently practical throughout, it nevertheless sometimes turns aside to discuss a theory and to explain a principle, and this it does with great lucidity. Nominally the second edition of a former work by one of the authors, it is now completely rewritten, and, to all intents and purposes, a new book. After a short historical review, the reader is at once introduced to some old friends. Cells and circuits, coils and contact-breakers, static machines and transformers, meet him in familiar array. The "captious critic" might feel disposed to ask whether the time has not arrived when it might be possible in treating of the Roentgen ray to presuppose a certain amount of elementary electrical knowledge on the part of the reader, and so spare the compiler an irksome task, and others a constant repetition of rudimentary electrophysics; the latter having been acquired once and for all from some of the recognised text-books. Still, if the repetition of such information be inevitable, it could not be better given than in the thirty pages devoted to it in this book; and the above charge certainly does not apply to a description of the "Tesla Oscillator," which will be new to many and interesting to all. After dealing with generators of electrical radiation, converters of Roentgen radiation, the manipulation of tubes, and other practical points, the medical and industrial applications of X rays are considered. Medical radiography and radioscopy are treated with great fulness of detail in their diagnostic and medico-legal aspects, and even radiotherapeutics and radiostereoscopy are not forgotten. It is a question whether this part of the book might not have been

improved by the co-operation of a medical editor; this might at least have saved the reader from such expressions as "ulnar and radius," "the sound or probane," the presence of "esudation," the "optical" nerve, the "diagnostical" value, and other evidences of lay nomenclature. Still, this is by far the best account of practical radiography in medical work that has yet appeared. In view of its authorship it need not be added that the photographic part of the book is all that could be desired. The volume concludes with an imperfect bibliography—we say "imperfect" partly because we look in vain for the ARCHIVES OF THE ROENTGEN RAY, an omission which we only mention to forgive.

COMMITTEE ON X RAY INJURIES.

The following were selected to act as members of the Committee of Inquiry of the alleged injurious effects of Roentgen rays: the President and Secretary of the Society (ex-officio members); Thomas Moore, Esq., F.R.C.S.; Dr. Barry Blacker; Mr. Ernest Payne, secretary to the Committee.

List of Questions.

A. MEDICAL.

1. Nature of injurious effects.
2. Description of the case radiographed.
3. Part exposed to rays.
4. Condition of subject:
   (*a*) Well nourished or emaciated.
   (*b*) Temperament nervous or phlegmatic.
   (*c*) Diathesis of patient.
   (*d*) Local condition of part exposed.
5. Did the patient complain of any feeling of warmth, tingling, or other sensation during or after exposure.
6. Duration of effects, temporary or permanent. Remarks.

B. ELECTRICAL.

7. Apparatus employed, influence machine, or induction coil, spark length, voltage and ampèrage used.
8. Form of tube; length from terminal to terminal.
9. Distance of tube from patient's body.
10. Number of exposures; interval, if any, between exposures; duration of each exposure.
11. Situation of tube with regard to body or limb of patient, *i.e.*, position of anode and cathode.
12. What covering or garment, if any, was used.
   (*a*) Material of which it was composed.
   (*b*) Rough or smooth.
   (*c*) Colour, if dyed.
13. Remarks.

Notes and Abstracts.

Another report of the application of X rays for medical purposes comes from Paris. M. Mascart, on behalf of Dr. Sorel and Prof. Soret, of Havre, described a case of elephantiasis which had been successfully treated with X rays.

A recent number of *Nature* (March 24) contains an article on "Skiagraphy after Injection of the Bloodvessels with Mercury," by Messrs. H. J. Stiles and H. Rainy. Other workers have obtained successful pictures by injections of different substances; those given by injection of mercury seem to be most successful. Two illustrations are given, one showing the arterial system in the head of a child, the other the veins in the chest. The brain in the first is *in situ*, and is injected through the carotid artery in the neck. The second illustration shows the result of an injection of the branches of the system of the superior vena cava. Radiographs of this kind ought to be of great use in assisting the interpretation of pictures of the chest in cases of thoracic aneurism and also of phthisis, which almost always present abnormal shadows of the heart with numerous other shadows, more or less distinct, crossing one another in all directions.

An injected brain was shown stereoscopically by Dr. Hedley at the conversazione of the Roentgen Society in November of last year, and afterwards at the Royal Institution.

Messrs. Trowbridge and Burback, in the *American Journal of Science*, describe some experiments with different forms of tubes, with one continuous conductor passing through them and no interval between the anode and cathode. X rays are given off from the conductor at right angles to its surface, and brilliant fluorescence is produced on the glass. In one case an aluminium mirror is fixed to the wire passing through the tube and a beam of rays is given off and thrown on the opposite wall of the tube.

The *Scientific American* (February 12) gives an illustrated description of the Dennis Fluorometer. As the name implies, it is an apparatus for localization and measurement by the aid of the fluorescent screen. Suitable angle-pieces are set up on a table in a line with one another so as to produce one shadow on the screen. First the surface of the body or limb of the patient is brought into line with the shadow of the angle-pieces and the position noted, a similar observation is next made with the hidden object or part to be measured, as the case may be, the distance between the parallel rays being noted or measured by the aid of a grid placed behind the screen. Distortions caused by the position and by the angle of the rays are thus eliminated. A second set of observations are made at right angles to one another with parallel rays as before. For facilitating observations from above and below, a section of the table can be removed and the screen, etc., fitted into it.

Description of Plates.

PLATE XL.

THE LOCALIZATION OF FOREIGN BODIES IN THE EYE BY MEANS OF THE X RAY.

By PERCY FRIDENBERG, M.D., New York, Assistant-Surgeon New York Eye and Ear Infirmary, Visiting Ophthalmic Surgeon Randall's Island Hospitals, etc.

About three months ago, Mr. B. H——, aged twenty-six, of Freehold, N. J., was brought to me suffering from the results of a gunshot injury, which had at once destroyed his sight. While out quail-shooting with a party of ten or more on the day before he was unfortunate enough to receive a charge of small shot (No. 9) in the left shoulder, the face, and both eyes. On examination, after separating the tense and swollen lids, the point of entrance of a shot was found a little above the cornea in either eye, and, corresponding to this, a penetrating wound of the right and left upper lids. The cornea and lens had escaped injury, but the vitreous was filled with blood, and vision reduced to perception of light only. The patient was admitted to the New York Eye and Ear Infirmary, where, under appropriate treatment, the inflammatory reaction subsided, without any signs of a purulent process in the eye. The vitreous, however, was still opaque from the hæmorrhagic exudation, and ophthalmoscopic examination was impossible. To decide the question as to whether the shot were in the interior of the globe, I determined to make an attempt with Roentgen photography.

It was evident that definite results could be reached only by obtaining a shadow-picture of the entire orbit to a distance in depth at least equal to the antero-posterior diameter of the eye. To accomplish this it was necessary to have the rays from the Crookes' tube pass directly through the bones of the skull, and to place the sensitive plate close in front of the eye. I succeeded in doing this in the following manner:

Two narrow Carbutt plates, about 3½ inches long, were cut out and trimmed roughly, so that they would fit into the inner margin of the orbit. The eyes were covered with some absorbent cotton, and the plates bandaged on in such a manner that they were at right angles to the line of the orbit. These plates were covered with black paper, into which pins had been stuck, one on the right, two on the left side, points down, to distinguish the plates after developing and printing, and to serve as a standard of density for any shadow-pictures which might appear. In this way close approximation of the sensitive plate to the eye was obtained, and all motions of the patient's head, which could hardly have been prevented during the necessarily prolonged sitting, were completely neutralized. For now the plate itself would move in a like direction and to the same extent, and prevent any distortion or clouding of the impression. Eye motions were practically excluded by the bandage.

The Crookes' tube was placed at the back of the head, about 14 inches from, and parallel

to the plate, which was exposed to the rays for nearly forty minutes. It was my intention to produce an over-exposure, so as to reduce as far as possible the disturbing influence of the cranial bones.

In this way a front-face view was secured, which I take pleasure in submitting to you herewith. The success of this experiment is due in great measure to the complete apparatus and technical skill of Mr. M. F. Martin, in whose X ray studio, at 110, East Twenty-sixth Street, the work was begun and finished. I wish to express again my sense of obligation for his interest in the case.

Holding the radiographs side by side and in contact, the wall of the orbit is seen as a narrow shadowy outline. The soft parts and the globe appear very much lighter. On the left side a number of small, approximately round, and denser spots appear—the shot-pellets themselves. It will be seen that all of them are apparently close to, or in contact with, the wall of the orbit. None is seen in the light space corresponding to the globe. On the right side, however, this is not the case. Here we find two foreign bodies, one near the floor of the orbit, the other on a line with the middle of the eye and possibly in its interior. To decide this, it was necessary to determine the depth of penetration, and locate each shot in its relation to the anterior surface of the globe. A view at right angles to the first, a profile view, was wanted. It was obtained by making the patient lie on his side, with his right cheek resting on a large photographic plate. The Crookes' tube was placed opposite the left temple, under the same conditions as before. The exposure lasted thirty-five minutes, and produced a picture of remarkable clearness. It will be seen, on comparing this with the front view, that the two foreign bodies in the soft parts of the right orbit are located at the back of the eye, which here appears as a grayish-white disc. In addition, we see the shot (five in number), which entered the left side of the face at different levels, one in the lower and one in the upper jaw, and two in the brow. We must bear in mind that the X rays penetrated the structures of the skull from the left side, projecting shadows from this as well as from the right side upon the plate. We have, as it were, one picture superimposed on the other.

The nearer a body is to the plate, the smaller and denser the shadow. This enables us to say definitely on which side of the head each and every shot-pellet lies, and, by comparison with the first view, to locate it quite accurately. It appears that both eyes were traversed by shot with such force that the posterior wall of the globe was perforated, and the missiles lodged in the depths of the orbit. Unfortunately, the extensive laceration and intra-ocular hæmorrhage have so nearly destroyed the eye that little can be done to restore sight. The patient can make out motions of the hand at 3 feet in the right eye; the left has only perception of light.

To sum up the principal points in which this method modified and improved upon the older ones, and which are of importance if radiography is to be of any practical use in this branch of clinical diagnosis, the following facts are evident: The whole extent of the eye and of the orbit is included in the skiagraph. Two views at right angles to one another are taken for purposes of combination. In the one, the closest possible approximation to the eye is effected by having two plates bandaged to the eye. The shadows thrown by the bones of the skull are eliminated as much as possible by extreme over-exposure. When for any reason we cannot obtain two

views, we may be able to dispense with the profile picture and to compute the distance of the foreign body from the plate by a calculation, in which the known factors are the diameter of the body itself, that of its shadow picture, and the distance from the sensitive plate to the Crookes' tube. The X rays diverge from the focal point of origin and produce a central projection of shadows, as do light rays coming from a finite distance. The same optical law holds good for both.

However unavailing our therapeutic efforts may have been in this particular case, these skiagraphs show, I think, that we have in Roentgen photography, modified in the manner above described, a simple and accurate method for determining the presence and, what may be even more important, the exact position of foreign bodies in the eye, and that, under more favourable circumstances, their removal may be rendered possible by its application.

PLATE XLI. (*a*).

NORMAL HAND AND ARM.

By CHARLES LESTER LEONARD, M.A., M.D., Skiagrapher to the University of Pennsylvania Hospital, Philadelphia.

The relative opacities of different structures to the Roentgen ray are well illustrated in this skiagraph. The gold of the rings and bracelet shows the greatest opacity, while the jet trimming on the sleeve, the bones, and the flesh show the gradations down to the less opaque. The length of the exposure was three minutes, the distance 12 inches.

PLATE XLI. (*b*).

SHOT-GUN ACCIDENT.

By CHARLES LESTER LEONARD, M.A., M.D.

This illustrates the result of a gun accident. The primary injury healed four years ago. The annoyance and interference with function which has lately shown itself made the removal of some of the shot necessary.

PLATE XLII. (*a*).

ENLARGEMENT OF HUMERUS.

By Dr. SNOW, Horsham.

E. B., age 52, attempting to get into a van when in motion, slipped, and was dragged by his arm some distance, receiving at the same time a severe blow on shoulder. Examined under

an anæsthetic, the joint appeared normal; and as the coracoid and acromion process seemed uninjured, I diagnosed fracture of the humerus high up, probably about the neck of the bone. Five weeks afterwards the radiograph was taken. What is the enlargement on the humerus? Is it the attachment of the scapular muscles torn away by being dragged? or had the humerus been fractured? Personally, I had little doubt about its nature.

PLATE XLII. (*b*).

OSTEO-SARCOMA.

By CHARLES LESTER LEONARD, M.A., M.D.

The specimen of which this is a skiagraph belongs to the Uhle collection of Peruvian antiquities recently added to the Archæological Museum of the University of Pennsylvania. Dr. Uhle's researches prove the age of this specimen to be at least 600 years. It is apparently an osteo-sarcoma of the radius. This would tend to demonstrate the prehistoric existence of carcinoma in America.

PLATE XLIII.

RENAL CALCULI.

By CHARLES LESTER LEONARD, M.A., M.D.

C. W——, nineteen years old, was referred to me by Dr. Edward Martin for a skiagraphic diagnosis. Clinical symptoms were present that indicated the presence of some renal or bladder lesion, but they were not sufficiently marked for an absolute diagnosis.

The skiagraph was made with a twenty-minute exposure, with the platinum of the tube at a distance of 20 inches from the plate, and with a vacuum equivalent to a 2-inch spark in air, as shown by the spark-gap in the shunt circuit of the Queen self-regulating tube which was employed.

The current was supplied by an 8-inch spark coil, and had sufficient ampèrage to keep the platinum at a vivid red-heat during the exposure.

The subsequent successful operation performed by Dr. Martin proved the correctness and value of the diagnosis, as the second stone was encysted in the inferior calix of the kidney, and would have escaped detection by any other means, as neither stone was palpable through the substance of the kidney. The operative procedure was therefore greatly facilitated by the skiagraph. The stones were uric acid in composition. Their size corresponded exactly with the measurements which had been previously made by my method of triangulation, which was described in May of last year (see *Annals of Ophthalmology*, vol. vi., No. 4, 1897).

This method consists of a series of repeated and differently placed exposures, from which

data are obtained for the construction of a series of known triangles, from which the exact size and location of a foreign body may be determined anywhere in the body. Its chief merit is its simplicity and mathematical accuracy.

PLATE XLIV.

By A. E. WELLS, M.D., Cuckfield.

These skiagrams exhibit in a remarkable fashion the diagnostic value of the X rays. Mr. Payne was carrying under his arm a large square board when he slipped and fell, crushing the first phalanges of his fingers between the edge of the board and the ground. This caused considerable swelling, pain, and stiffness of the fingers, and the X rays showed the condition that appears in Fig. 1, a slender fragment of bone being separated from the ulnar side of first phalanx of the middle finger. The finger is viewed obliquely from behind and from the ulnar side, and since this widens the apparent gap between the fragment and the bulk of the bone, it is plain that the detached piece lies towards the palmar aspect. One is thus led to the conclusion that the fragment is probably the narrow lip of bone to which the sheath of the flexor tendon is attached.

That such a fracture would ever occur would, apart from this case, be difficult of belief, and without the assistance of X rays its diagnosis would certainly be quite out of the question.

In the second print it is of interest to notice the commencement of bony union, the gap between the fragment being bridged across in three places.

In Fig. 3 the union is more complete. Fig. 1 is an oblique view at the time of the fracture, October 20, 1897 ; Fig. 2 December 29, 1897 ; and Fig. 3 March 28, 1898.

PLATE XLV.

OSSIFYING SARCOMA.

By Mr. COXETER.

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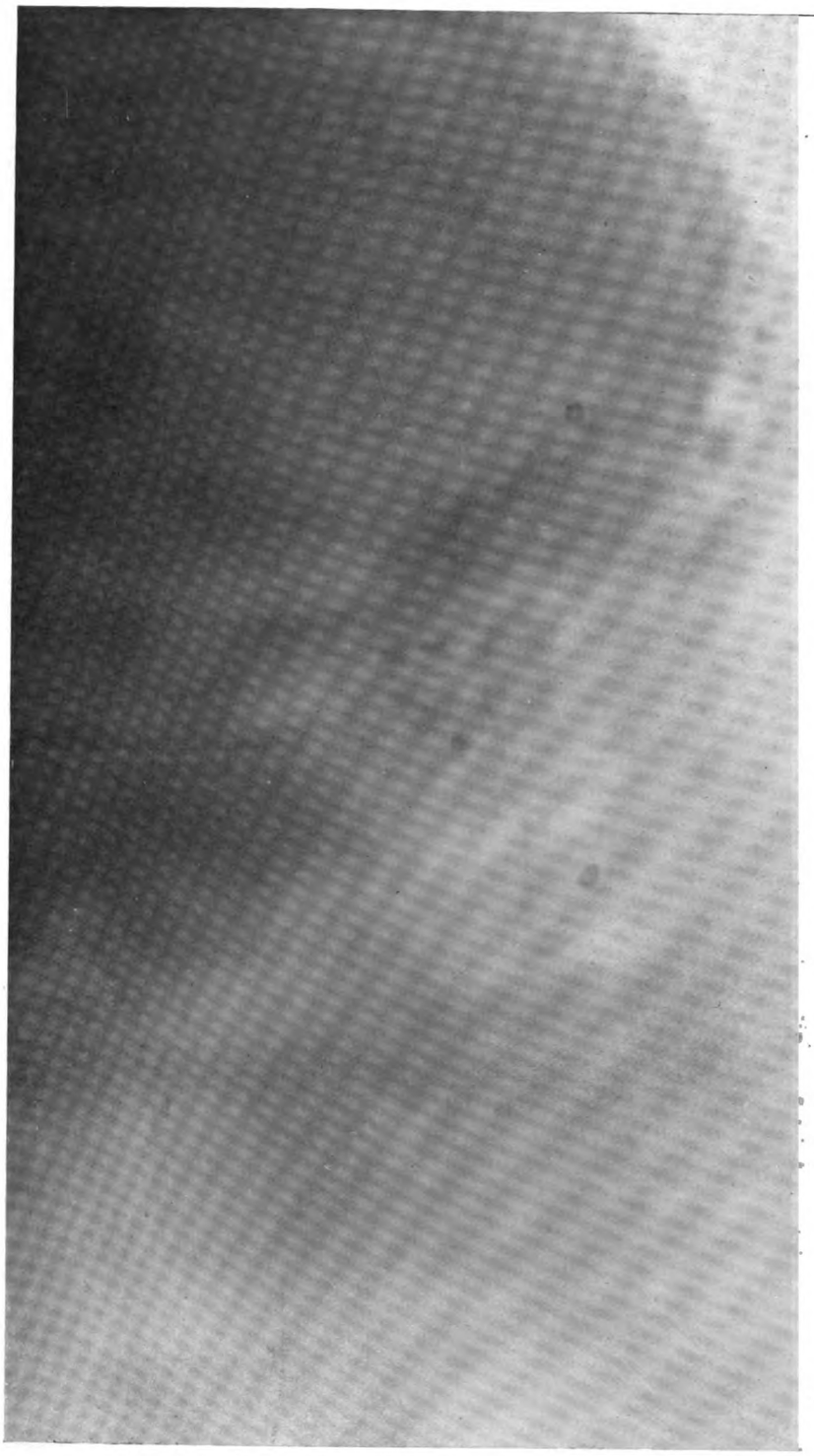


LOCALIZATION OF FOREIGN BODIES IN THE EYE.

(By CHARLES LESTER LEONARD, M.A., M.D., Radiographer to the University of Pennsylvania Hospital.)

PLATE XL. (*a*).

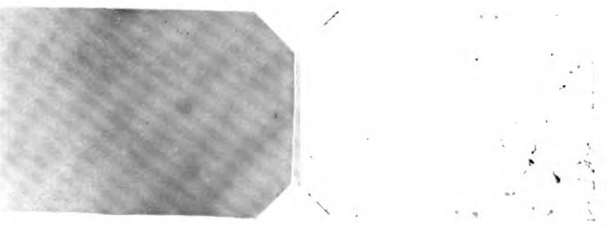


PLATE XL. (*b*).

(*"Archives of the Roentgen Ray."—Copyright.*)

NORMAL HAND AND ARM.

(*By CHARLES LESTER LEONARD, M.A., M.D.*)

PLATE XLI. (*a*).

(*"Archives of the Roentgen Ray."—Copyright.*)

SHOT-GUN ACCIDENT.

(*By CHARLES LESTER LEONARD, M.A., M.D.*)

PLATE XLI. (*b*).

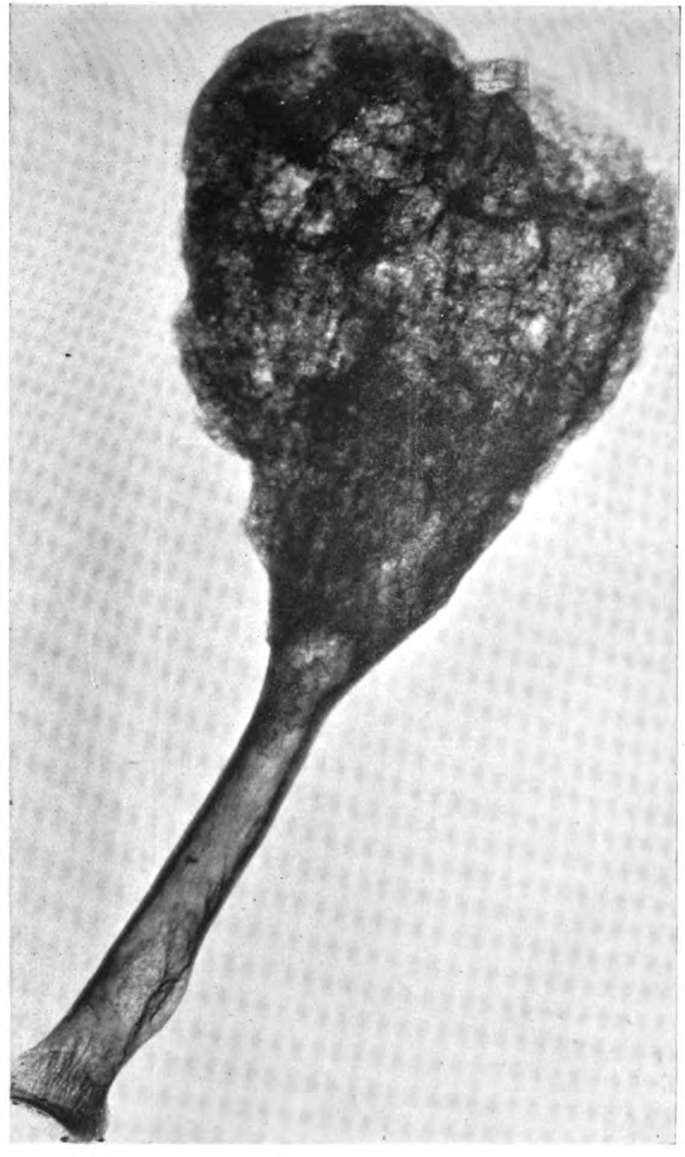
(*"Archives of the Roentgen Ray."—Copyright.*)

ENLARGEMENT OF HUMERUS.

(*By Dr. SNOW, Horsham.*)

PLATE XLII. (*a*).

(*"Archives of the Roentgen Ray."—Copyright.*)



OSTEO-SARCOMA.

(*By CHARLES LESTER LEONARD, M.A., M.D.*)

PLATE XLII. (*b*).

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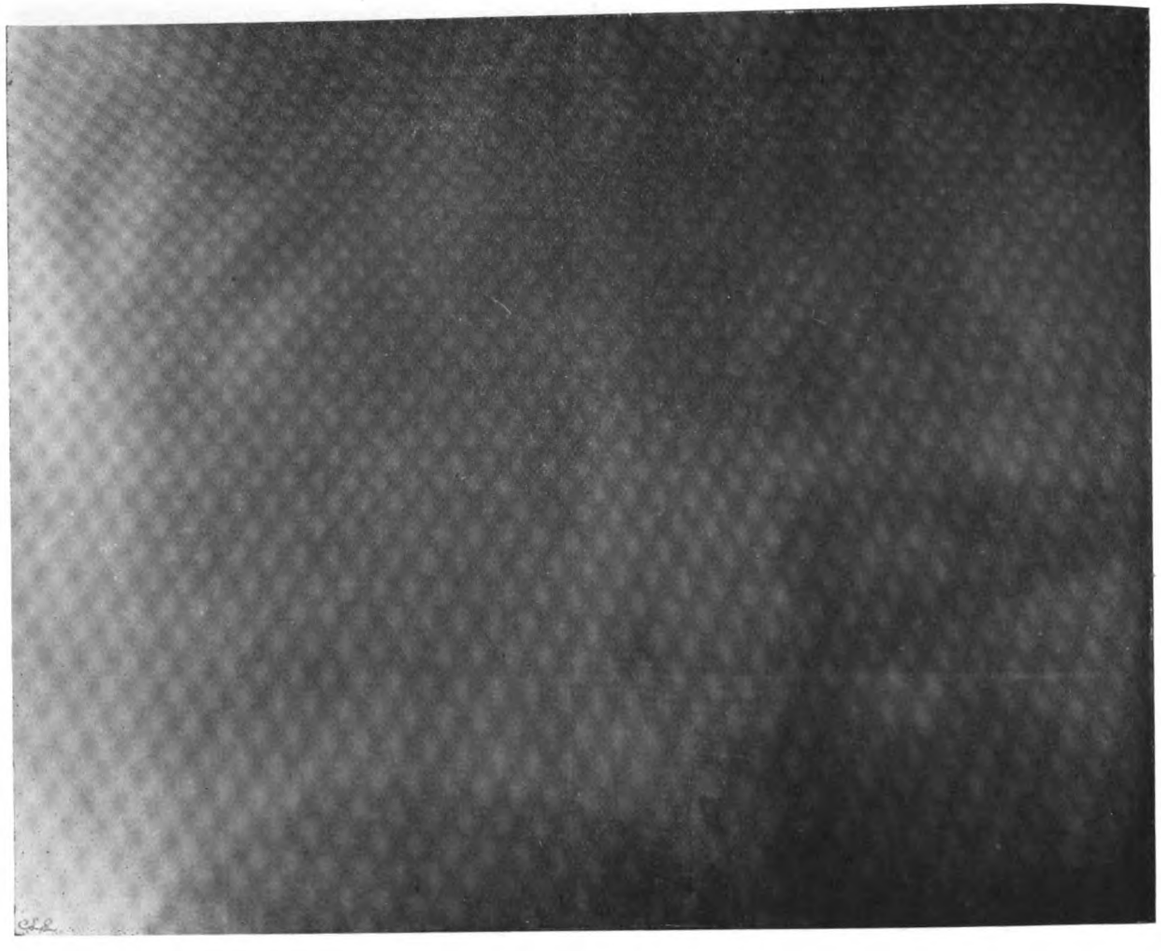

RENAL CALCULI.

(By CHARLES LESTER LEONARD, M.A., M.D.)

PLATE XLIII.

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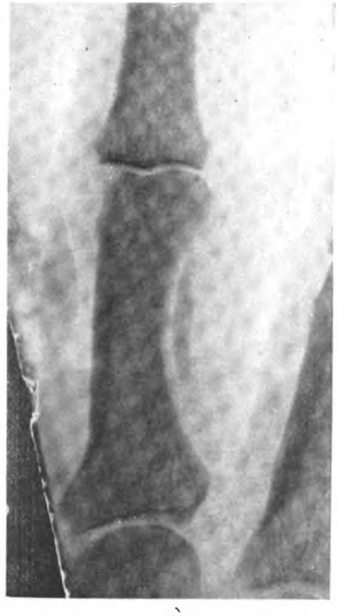


FRACTURE FIRST PHALANX MIDDLE FINGER.

(By ERNEST PAYNE, M.A.)

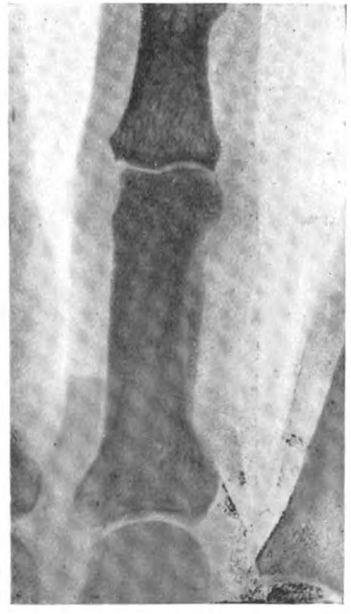
PLATE XLIV. FIG. 1.

(*"Archives of the Roentgen Ray."—Copyright.*)

COMMENCEMENT OF BONY UNION.

PLATE XLIV. FIG. 2.

(*"Archives of the Roentgen Ray."—Copyright.*)



COMPLETE UNION.

PLATE XLIV. FIG. 3.

(*"Archives of the Roentgen Ray."—Copyright.*)

OSSIFYING SARCOMA.

(*By Mr. COXETER.*)

PLATE XLV.

(*"Archives of the Roentgen Ray."—Copyright.*)

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— OF —

THE ROENTGEN RAY

(*Formerly* ARCHIVES OF SKIAGRAPHY).

THE ONLY JOURNAL IN WHICH THE TRANSACTIONS OF THE ROENTGEN SOCIETY OF LONDON ARE OFFICIALLY REPORTED.

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ARCHIVES OF THE ROENTGEN RAY.

Induction Coils. IN the present issue we print a report of the discussions which arose at the meeting of the Roentgen Society upon induction coils and their contact-breaks. This is a topic of deep interest to experimenters of all classes, and it is satisfactory to note the unanimity with which those best able to judge testified to the excellent mechanical construction and performance of British-made instruments. If there is one instrument in which, above all, sound materials and good workmanship are essentials, that instrument is the induction coil. The possessor of a good induction coil made by our leading instrument-maker should cherish it as the violin-player cherishes his Stradivarius or his Guarnerius.

X Rays in Warfare. It is interesting to place side by side a paper read at the Royal United Service Institution, by Surgeon-Major W. C. Beevor, on his experiences with the Roentgen rays in the Tirah campaign, and the replies given a few days afterwards in the House of Commons by Mr. Brodrick, to questions by General Russell and Sir J. Fergusson with reference to the supply of X rays apparatus for the recent operation in the Soudan. Surgeon-Major Beevor described and showed radiographs of different cases of bullet-wounds where valuable use had been made of the rays. Amongst these may be mentioned the case of a sergeant who had been wounded in the instep by a bullet, the fragments of which were extracted with the exception of one piece, which prevented him from walking. This last fragment was discovered under the heel by the aid of the rays. The paper went on to maintain that it was now the duty of every civilized nation to supply its wounded in war with an X ray apparatus, not only at base hospitals, but also close at hand wherever fighting might be.

Mr. Brodrick informed the House that the senior medical officer had gone carefully into cases cited, and had been unable to trace any single case amongst the wounded in Egypt where the apparatus would have been specially useful, or in which an operation would have been more successfully carried out by the use of the rays. If the latter of these very opposite medical opinions be too sceptical, it is possible that the former is too sanguine. We are glad to learn that a *via media* has been discovered, and that, at any rate, two sets of apparatus are already in Egypt, and that a third is being sent out. Although the rays were not wanted after the battle of Atbara, they may, perhaps, be found useful after the fall of Khartoum.

Professor Küttner, of Tübingen, who took part in the campaigning during the last Greek war on behalf of the German Red Cross Society, concludes his report with the opinion that the Roentgen rays are of great use in war, but only for fixed hospitals, such as reserve hospitals and those installed in fortresses, whilst for moving field hospitals their application is very limited.

We look forward with interest to the report of the principal medical officer of the United States troops engaged in Cuba on the use of the Roentgen rays on the battlefield.

The Action of X Rays on Micro-organisms. Experiments as to the effects of X rays on bacteria have been carried out by many workers with very different results. We print at p. 13 a contribution to the subject, by Drs. Wolfenden and Forbes-Ross, read at the last meeting of the Roentgen Society. The authors selected *Bacillus prodigiosus* for investigation, and found that in this case the X rays had a stimulating effect on its development. The experiments are being continued with other bacilli.

Dr. Francis Pott has experimented on the bacillus of Koch, and concludes that the X rays have no effect after exposures of eleven hours' duration. On the other hand, Dr. Sinapius, of Vienna, has treated patients suffering from tuberculosis, and claims that beneficial results have been produced, although he does not consider the effects to be due directly to the action of the rays.

Rieder* considers that his researches show that bacteria (vibrion chol., staphylococcus, streptococcus, diphtheria bacillus, bacillus of tubercle) are killed in cultures (agar, serum, gelatine) when they have been exposed to the rays for an hour. Cultures in broth resist for a longer time. He concludes that the rays possess a bactericidal action more or less absolute. This effect is not due to the heat they give off, for the temperature of the culture medium is scarcely raised at all; neither is it due to any chemical action of the rays upon the culture medium, for if the latter be submitted in the first instance to the action of the rays, the bacteria afterwards added undergo full development.

L. Boromo† concludes from his researches that X rays do not exercise any action either upon chromogenic bacilli (*b. prodigiosus* and red b. of water), or upon the bacilli of tetanus, malignant œdema, or tuberculosis; that they quicken the sporulation of *b. subtilis*, but retard, on the contrary, that of *b. anthracis*, the toxic properties of the latter being even slightly diminished.

R. Müksam‡ has made experimental researches upon guinea-pigs, which, after having been inoculated with tuberculosis cultures under the skin, in the peritoneum, joints, etc., were submitted daily for one hour to the X rays. These animals all succumbed to tuberculosis, but a little later (about fifteen days) than the control animals, which had not been rayed. The author concludes that the rays attenuate the virulence of the bacillus, but that they do not stop the progress of the disease. At the fourth Congress for the Study of Tuberculosis, at Paris, July 27 to August 2, papers were discussed on the use of X rays for diagnosis, and for treatment in cases of tuberculosis. The President stated that the X ray had no power to check the growth of Koch's bacillus, nor its progressive destructive action on the organism. On the same occasion Bergonié and Teissier reported that the X ray had no effect in retarding the disease. Rodet and Bertin-Sans, having submitted guinea-pigs to the action of the rays, conclude that death was generally hastened by the treatment.

Referring to the cognate subject of X rays and plant life, Atkinson§ describes his experiments on the effect of "raying" plants and fluids. He finds that the rays are absorbed by vegetable tissues, but does not find any external lesions even after exposure of many days.

* *Munch. med. Wochens.*, 1898, No. 4, p. 101.
† *Bollett. della Soc. Lancisiana degli Osp. di Roma*, an xvii, fasc. i., p. 287.
‡ *Deut. Zeit. f. Chir.*, No. 4, p. 364, 1898.
§ *Science*, January 7, 1898.

Maldiney and Thouvenin* studied the effects on germination of the rays by submitting to their influence grains of various species. They conclude, after guarding carefully against experimental error, that X rays hasten germination, at least in the case of bindweed, cress, and millet, but that they are without influence on the formation of chlorophyll.

Tollomei,† adopting the method of Prillieux, which consists in determining the quantity of gas disengaged under the action of light, concludes that the effect of X rays in this respect is very slight, and not greater than that of other light. In experimenting with mycoderma aceti, he noticed that the development which goes on in the dark, and is hindered by sunlight, is also decidedly lessened by the action of X rays. It is the same with *Bacillus anthracis*—the activity of these cultures is lessened. He has also noticed the destructive action of the X rays upon sporulation; and the outcome of his work is the conclusion that, in the above respects, the action of X rays is not different from that of ordinary light.

In all experiments with bacilli it would seem a point of supreme importance to take special precautions to make certain that the effects are due to the X rays alone, and not to any other electrical influences. The possible effect of the discharge from the wires and tube may be clearly illustrated by the aid of a gold-leaf electroscope. If one of these instruments be placed near a tube in action, it will soon show a charge by the separation of the gold leaves. The tube or other receptacle containing the bacillus might be covered or surrounded with metal gauze, or gold-leaf or tinfoil, carefully earthed by a wire connection in order to screen the cultures from electrostatic and electrolytic effects.

THE ROENTGEN SOCIETY.

A GENERAL MEETING was held May 10, 1898, at 11, Chandos Street, Cavendish Square, Professor SILVANUS P. THOMPSON, F.R.S., in the chair.

The following names were balloted for, and declared by the President to be duly elected as members: Leon Gaster, Walter D. Jamieson, T. Maltby Clague, F. H. Buhl, Arthur Talbot, John Lynn Thomas, W. Reginald Cookson, Sydney F. Walker, Frank S. Pepperdène, M.A., Ph.D.; Margaret Mary Sharpe, L.R.C.P., L.R.C.S.

* *C. R. de l'Acad. des Sc.*, No. 7, p. 548, February 14, 1898.
† *L'Éclairage Electrique*, February 25, 1898.

Edin.; Leslie Miller, A.I.E.E.; Harold H. Simmons, A.I.E.E.; Ernest Greville, M.B., C.M. Edin.; Lewis Jones, M.A., M.D.; Alfred Apps, M.I.E.E.

The following name was nominated by the Council for election at next meeting: Max Kohl, of Chemnitz.

The PRESIDENT read a letter he had received from Mr. A. W. Isenthal, a Member of Council, now visiting Wurzburg. Mr. Isenthal had called on Professor Roentgen and tendered him the collective greetings of the Council, and the Professor had asked him cordially to reciprocate them, and to say that the growth of the Society was a source of great satisfaction to him.

The PRESIDENT announced that the next general meeting would be held on Tuesday, June 7, when papers would be read by Mr. Campbell Swinton and Mr. T. C. Porter.

The SECRETARY showed some skiagrams of a bullet-wound in knee, received from Mr. Marsh.

The following paper was then read by Mr. A. APPS: "Notes on the Description of a New Induction Coil, in the *Electrical Review*, February 4, 1898," p. 155, illustrated by diagrams, etc.:

I submit that this subject should not remain unnoticed, and it is especially the case with reference to the objects of the Roentgen Society. It is necessary to reduce the present unsatisfactory methods of X ray work to an exact system. To do this the best appliances will become necessary.

In the following remarks the various points of interest will be discussed in the order in which they occur in the *Electrical Review*. The paper read, or the statements made, before this Society about two months ago were, I understand, substantially the same as in the *Electrical Review*, and the following observations may, therefore, be regarded as a discussion:

1. It is asserted that the Ruhmkorff's coil is the only one in common use. In this coil the winding of the secondary is in layers, like cotton on a reel, and the contact breaker is a hinged lift arrangement placed horizontally under the magnetic core-end. The reaction after breaking contact is due to gravity. The results were so uncertain that Dr. Bently and Mr. Ladd, about 1854, gave considerable attention to this subject, and devised an upright contact breaker, with a spring of steel and copper, far superior to Ruhmkorff's. In 1868 a patent was taken out by the writer for an improvement upon this for an improved coil (also subsequent patents), and *not* including any details of the Ruhmkorff coil. The improved instrument—I may say the new form — has been made and exported to almost every country for upwards of twenty-five years. I submit, therefore, that the statement referred to is inaccurate.

2. It is said that in all coils the efficiency is low. That is no doubt true of the Ruhmkorff coil of thirty years ago. It was at that time an instrument of great merit, and gave $1\frac{1}{2}$ inches spark, as compared with 8 inches in the new form, of which there are specimens before you. The efficiency—8 inches instead of $1\frac{1}{2}$ inches —certainly is not low by comparison.

3. The length of secondary wire and labour of winding are said to be another objection; but in the modern coil of 8 inches spark (about 20 centimetres) the secondary is not of great length, being about 6 miles, and a few hours' work only is necessary to place it in position; whereas $7\frac{3}{4}$ miles appears by the measurements given to be required in the "new" coil described in the *Electrical Review*, to produce the 20 centimetres spark.

4. It is further objected that the insulator is easily pierced, and burning may take place. The best answer to this is that the authors of the paper now under discussion may, if desired, see many coils of the new type which have been at work for more that twenty-five years, and in some cases worked almost daily, with no diminution in power, nor change in insulation. Since writing this paper the author has used a 10-inch coil, made twenty-eight years ago, in which it was not found possible to prove a falling off in the spark of $\frac{1}{16}$ inch.

5. Referring to the question of weight, an 8-inch coil is sufficient for almost any work, and is not inconveniently heavy. The Ruhmkorff coil of 1860 weighed about 20 lb., and if increased on the same scale for 8-inch spark, would reach, say, 107 lb., which would be too heavy for X ray work, where a portable set of instruments is required.

With regard to size of bobbin, I would call attention to the diagram, where 3-inch, 4-inch, 6-inch, and 10-inch sectional areas of bobbins are shown, also opposite the 4-inch, which gives a 7-inch spark, the large bobbin of Messrs. Rochfort and Wydts.

6. These authors also assert that defective insulation is the characteristic of all coils as at present made. The answer to this is that the insulation in the new coils is not found to decay, and, so far as can at present be judged by an experience of nearly thirty years, they may remain perfectly good for a hundred years or more, no sign of fault being found after the most delicate tests

on coils twenty-five years old and upwards. The advance in electrical science doubtless leads us to think that the best insulation should be provided, but there are many points to be considered, such as portability, liability to fracture, chemical action of one part upon another, danger of explosion, ignition, etc., to which we shall refer later.

No doubt insulation against the 400,000 volts mentioned (16-inch spark) requires great care. In this connection it may be remarked that the induction coil, under the patents referred to, made by the author for the late Mr. W. Spottiswoode, formerly President of the Royal Society, gave a spark of 44½ inches (as long as the bobbin), which, according to the table of spark-lengths and corresponding voltages by Drs. De la Rue and Müller, would be about 1,000,000 volts; the insulation, however, did not appear to be insufficient in any part. Those who wish to obtain further particulars of this coil may refer to Mr. Spottiswoode's Royal Society Paper (it will be found reprinted in the *Philosophical Magazine*, January, 1877, p. 30).

7. Fluid or semifluid insulators are next recommended. It cannot be conceded that any advantages are gained by such means, and although it is claimed that the deposition of carbon (which is a conductor at once destroying all insulation) is prevented, yet it is impossible to grant this, and a longer experience will prove this view correct. Wherever there is electrical stress, an action producing carbon takes place in all oil insulators, and in a general way, I need only say, the use of oil in condensers and transformers is comparatively limited, and likely to be, even for those very low potential differences, discarded altogether. Very recently the writer has seen a 24-plate condenser, with only a potential difference of about 20,000 volts, taken to pieces, and at the bottom (the plates being vertical) quite an accumulation of carbon had been deposited.

The amount of insulation obtained by oil is not generally very great. In the January number of *Science Abstracts*, p. 16, air being taken at unity, oil is said to give from 0·9 to 7·8 times the insulation of air. In common practice oil is taken as giving about three times the insulation by air. Much depends, however, upon the *nature* of the electrical discharge or tendency to discharge, apart from voltage or potential difference. It is said, for example, that with an extremely high frequency, in the alternate current discharge, conductors and insulators behave alike.

Now, it is clear that the carbon is formed close to the electrically-charged parts of the apparatus, and it would, therefore, be produced within the spaces between the turns of the secondary wire; from which it could not sink away by gravitation.

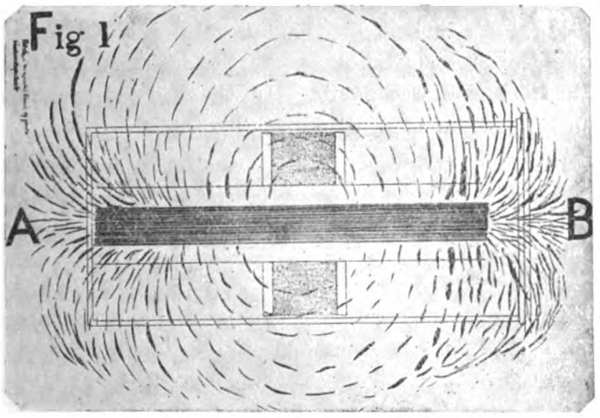
In 1870 the late H. C. Baines, of Pembroke College, Oxford, in conjunction with the writer, tested the use of oil as a means of increasing the insulation of the secondary coil, and discarded it, for, among others, the reasons stated.

In *Science Abstracts*, No. 1, p. 17, insulating materials are discussed, and a fireproof quality is said to be essential. If a very thick oil be employed, it is within the limits of reasonable probability that a body of explosive gas may be collected as a bubble and fired in the interstices of the secondary winding or other internal part, and this might also occur when a more fluid form of oil is used. I have seen bubbles of gas come to the surface, and oil used for insulating exploded, and more especially in the case of paraffin, which is classed as one of the best insulators (not perhaps better than resin-oil, but generally of greater fluidity), it cannot be denied that there is great danger. Such considerations, and the unavoidable decomposition acknowledged by Messrs. Rochfort and Wydts, appear to greatly limit the use of all oil insulators, especially where high potential differences are employed. There are also certain peculiar forms of action, which cannot be discussed now, but which are of an exceedingly important nature, all tending to prevent the use of fluid insulators in coils. Permit me to quote from Ebert and Wiedeman (*Science Abstracts*): "Rarefied gases are often better conductors than metals." There are doubtless cavities in a secondary coil where the so-called silent discharge is more or less produced, and it is only necessary to excite an unfinished coil in a darkened room to see this. There are numerous little sparks in addition to the bluish haze. Tesla speaks, in the American style, of a coil being a "mass of fire," and this being so, it is a certain means for firing gases. (See Tesla's Lecture, p. 14. Published by Johnston, N.Y., 1896).

The extreme facility with which gases may be ignited is shown by the fact that a spark of $\frac{1}{20}$ inch long, and so thin as to be barely visible in a darkened room, will fire gas. I have been successful with a common magneto-medical machine by attaching a small condenser to the two parts of its contact breaker. Possibly a smaller spark would fire gas.

8. Fig. 1 shows the proportions and full size of the

coil, insulated by oil, described and figured in the *Electrical Review*. The secondary bobbin is 6 inches in diameter by 2 inches in width, and after deducting the space occupied by the primary, the bobbin contains 45·96 cubic inches. Within the coil there are 41,352 turns of wire, in total length 7¾ miles, the diameter of the wire being, as stated, 0·16 mm. diameter = No. 39 English gauge = 0·0064 inch diameter, which would be unusually fine for a well-made coil, giving a 20 centimetre spark (about 8 inches). Both the length and the number of turns are excessive, the extremely small wire



also tending to spoil the effect. It is presumed that the space shown as secondary coil is filled by the wire, covered in the usual way.

The Form of the Coil.

A large diameter bobbin, over the centre of the primary coil, was tried by Mr. Ladd, about the year 1860, and abandoned on account of the waste of secondary wire, due to large diameter, awkward size, and increased mechanical and electrical difficulties in construction, and until now has not since been heard of. The necessity for excess of material is accounted for on noticing the magnetic lines of force approximately indicated in the diagram and coloured red; the bobbin being placed in the middle only, a large and useful space is left, hence the poor effect produced. At the points A and B, near the poles, a part of the secondary wire should be coiled. I have noticed that a few turns, more or less, in this part make a great difference to the spark effect. It has been, for many years, a matter of common knowledge, taken advantage of by makers of all kinds of electro-magnetic appliances, that the copper-wire intended to cut the lines of magnetic force must be placed in those lines, and in all respects to the best advantage. Upon the realization of such conditions the efficiency of a system undoubtedly depends. The lines shown in Fig. 1 have been drawn from a figure produced by iron-filings when using as a magnet a primary coil similar to that described in the *Electrical Review*.

9. In conclusion, a comparison is made of the "new" coil with a Ruhmkorff coil of large size, containing about 13 lb. of thick secondary wire. This does not appear to be a fair comparison, to take a coil of thirty years ago, for if the large coil were improved up to date, the spark would not be 8 inches (20 centimetres), but at least 12 inches to 15 inches.

At this point I submit some general observations on the economy of materials. It is quite a mistake to employ only a short length of secondary wire, especially if it be wound to a large diameter. Many experiments and calculations confirm this view, but this is not the time or place to discuss such matters at length. Let one example suffice. In a coil, nominally a 3-inch spark instrument, a spark-length of 6½ inches was obtained; but such extreme lengths from a small coil do not pass rapidly, and are, therefore, unsuitable for X ray work. It may be asked why the wire should be so limited: it is a matter of expense; but this does not apply to so great a degree in the case of iron wire, now largely used by makers of an inferior class of instruments. Such wire soon rusts asunder, and then the coil is quite useless, not being worth repairing. There are also other devices for making coils to last a short time.

10. It is claimed that the spark of the "new" coil has double the strength of the Ruhmkorff of thirty years ago, which cannot be admitted without proper measurement. It is notorious that induction-coils follow very closely the now well-known law of transformers, used for electric-lighting, etc.; the turns of wire placed in a magnetic field having currents induced in them proportional to that field. As an illustration, may I mention here that by the use of tabulated data an induction-coil, closed circuit transformer, was lately made to a required spark-length for testing underground lines for faults, and the results were quite in accordance with the calculations?

In conclusion, I desire to thank you for the way in which you have received my paper, also personally to thank Messrs. Rochfort and Wydts for the trouble they have taken to bring this subject before the Roentgen Society.

A discussion followed:

Mr. SWINTON said he worked with an Apps coil, which he believed was twenty-five years old. He certainly could testify to its durability, for he had subjected it to tests, fair and unfair; he had even put it on to the direct current from the electric mains, and it seemed to make no difference to it. He did not agree with Mr. Apps' remarks as to the unsatisfactory nature of oil as an insulator. He had used it, and found it answered well; and, indeed, in one of his experiments he had used water, and even that seemed to act satisfactorily. He thought there was a great fault in all induction coils, and that was, that the amount of energy obtained from the secondary, as compared with that put into the primary, was not satisfactory. From trials he had made, he thought not more than 30 or 40 per cent. of the energy supplied to the primary could be obtained from the secondary; whereas in transformers he thought the yield was 90 to 95 per cent. from the secondary. He also thought there must be a good deal of waste in condensers.

Lord BLYTHSWOOD said he had used oil as an insulator, but he had found that when using high tension currents of, say, 200,000 to 400,000 volts, it was absolutely necessary to filter the oil through carbon filters. In working with his coil he had had many contradictory and inexplicable results, and he felt he could not add much of practical value to the discussion.

The PRESIDENT said that when M. Rochfort had exhibited his coil to the Society, he certainly had complimented him because he felt that every attempt to improve induction coils should be encouraged. He thought Mr. Apps must have made a mistake in estimating the quantity of secondary wire used by M. Rochfort to be over eight miles. In the description of the coil in the *Electrical Review* the particulars given were most precise, and the quantity of secondary there named was a weight of 600 grammes, which, being only 0·15 millimetre thick, worked out at about 2 miles in length; and it seemed to him these figures looked reasonable, taking into account the other dimensions given. Mr. Apps had taken exception to M. Rochfort comparing his coil with a Ruhmkorff, and Mr. Apps had assumed that this implied one of the old type. The President did not think it was necessarily so. He thought M. Rochfort had used the term in a general way, though he did not believe that he had compared it with so good a coil as those made by Mr. Apps. The President said he yielded to none in his admiration for the admirable work Mr. Apps had done in improving induction coils; he had shown the greatest care in the smallest details, and even the brass he used for his contact springs was made of some special alloy, which was known as "Apps' brass." He quite endorsed what Mr. Swinton had said as to the durability of Mr. Apps' coils. He had on one occasion left his Apps' coil on the alternate current mains for a considerable time, but the coil seemed none the worse for it. He thought the output of current of an induction coil was unsatisfactory, owing to the unbalanced self-induction; and he was certainly of opinion that a perfect induction coil had yet to be devised.

Mr. APPS replied, and said he still thought he was right in his calculations as to the length of wire on M. Rochfort's secondary. He thanked the members for the reception they had given his paper.

A paper was then read by Dr. J. MACINTYRE, F.R.S.E., "Some Notes on Contact Breakers," illustrated by lantern slides:

Any paper dealing with the subject of contact breakers must necessarily be incomplete if the standard be a consideration of all the types which have been employed. Mr. Apps has stated that hundreds of contact breakers have been employed for different purposes, and although these vary considerably in detail, the principles involved are limited. Apart from a matter of convenience, it may be clearly stated therefore that interrupters have been employed for different purposes, and so in this paper it will only be necessary to refer to the principal types which have been employed for X ray purposes with the ordinary induction coil or transformer. This limitation is necessary because the question before us is not the arrangement for special instruments devised for the production of oscillating discharges by Telsa, nor for influence machines. Judging from the discussion upon Mr. Wimshurst's paper which took place at the last meeting of this Society, it is quite possible that our ideas of the special kind of transformer, or perhaps influence machine, may be modified; but, as I have intimated, for reasons which need not here be stated, it is desirable that the ordinary induction coil should be carried to its maximum efficiency, and the consideration of the make and break consequently is of extreme importance.

Interrupters have been classified by different observers in various ways, such as the coming in contact by direct opposition of two metallic surfaces as in the ordinary

spring arrangement, the gliding movement as in the rotatory, or the mercury, according as we have contact rods dipping into this metal. Again, they have been divided into those which are introduced within the primary circuit and those which are not. Further, they have been classified as those which are driven by a motor or other mechanical contrivance, and so on.

While all this is very interesting, it does not admit of anything like a scientific basis, and consequently we must attempt to approach the subject from another standpoint. Before doing so, however, it may be useful to consider types of these, and we must naturally, therefore, begin with the very common and extremely useful modification of the spring interrupter with which we are all so familiar in the Apps coil. Its universal use testifies to its great practical advantages, and amongst these may be mentioned that by one of the two springs the number of vibrations may be regulated, and by another, or by a combination of both, the intensity of the spark is increased, and the current through the primary coil somewhat regulated. Within certain limits, and particularly for small coils, we have nothing but commendation to offer, and for practical purposes in ordinary Roentgen work it has done, and will doubtless continue to do, a large share of the work. Let it be noted, therefore, that by means of this interrupter we may regulate the number of vibrations, we may increase the intensity of the excitement, and vary the quantity of current, as we have already stated, within certain limits. The Duprez modification of the same principle is another instrument which must not be overlooked in a paper of this kind, inasmuch as it works very rapidly and well—a factor of no small importance where screen-work is employed—and for it may be claimed the same advantages to which we have already alluded. The Vril interrupter, also built upon the same principle, is extremely good, and while it includes the advantages of the others, it introduces another factor, inasmuch as it is provided with a separate spring, thus allowing the armature to move a certain distance without breaking the contact; and here we would note particularly an extremely good step is suggested by the fact that the time the two pieces of metal are in contact can be regulated. This same principle has been introduced into contact breakers as supplied with the machines of Aylsworth and Jackson (New Jersey), and others. The General Electrical Company of New York have also introduced an interrupter capable of a considerable amount of adjustment.

Passing now to the type of machine which has been largely used in the American Continent, we have the gliding movement referred to; but here the contact is through a small wheel in which insulators have been placed at regular intervals. The apparatus is driven by a motor, and again we note that by this means we can vary the number of vibrations, we can increase the intensity by increasing the speed of the machine, and, lastly, the quantity of current of the primary coil may also be varied. Coming now to the mercury forms, we have many varieties of these. In the majority of them the rod is brought into contact by mechanical or electromagnetic force in the primary or other circuit, and its simplest form is a combination of the ordinary spring movement dipping in and out of mercury. Max, Kohl, Schall, Payne, and others have devised different forms. (Photographs of these were thrown upon the screen.)

There are many minor difficulties in connection with these, but nothing further need be stated here, beyond the mention of such difficulties as the controlling of the spark by the addition of alcohol, petroleum-oil, etc. In all these forms the number of vibrations may be regulated, the intensity changed, and the current passing through the primary coil increased or diminished.

That all writers upon the subject are agreed upon the necessity of certain conditions being complied with in interrupters is proved by the constant reference to such in the literature of the subject. Thus, one writer will refer to the suddenness of the shock; another to the complete make and constant break; others to the duration of the contact, the flow of the current, the intensity more than the rapidity by such vague terms as "short," "sharp," "snappy," "vigorous," as quoted by Morton. Doubtless each writer has in his own mind a particular condition of the interrupter when he refers to such terms, but it occurred to me at a very early date, as shown in a paper read to the Edinburgh Royal Society in the early part of 1896, that the actual conditions required might be somewhat more definitely stated. This was the result of several observations upon the condition of the tube with the mercury interrupter and ampère meter, and the unexpected success which followed a few vibrations of the mercury interrupter. The tube was with this more brilliantly illumined, and remained longer luminous in the dark afterwards; photographs were more quickly taken, and shadows on the fluorescent screen (especially in the deep-seated structures) were much better defined. In fact, it was as early as this date that I first obtained

anything like an idea of the possibility of instantaneous photography, and the value of the interrupter in the work. It was resolved, therefore, to submit the question to a definite series of experiments, and with this view the arrangements and experiments in the next section were devised.

Special Experiments.

The aim in all these was to obtain as nearly as possible the same condition in photographs, or viewing the same object, in a series of successive experiments. First, the current was derived from the main; secondly, a special rheostat was arranged, so that any number of volts or ampères could be used; thirdly, Lord Kelvin's ampère and volt metres were put into circuit, so that the slightest variation could be immediately controlled. The discharge rods were kept at precisely the same distance. The tubes were kept as nearly as possible at the same vacuum in some experiments by heating, and in others by tinfoil on the tube, as suggested by Mr. Wimshurst, the slightest variation in the condition of the vacuum being immediately tested. The same coil was always employed, an 18-inch spark Apps-Newton pattern with the same condensers. The screen specially selected was the barium-platino-cyanide, but many others were also tried. The results were tested upon the same class of photographic plates, the developer being the same, and the process of developing and fixing being as far as possible in the same series of experiments carefully regulated with the same object. The number of vibrations of the coil in a given time were recorded, and the exact time was also registered. It need hardly be said in addition that the same object was used, and the distance of the plate from the tube all carefully measured, so that each experiment was as nearly as possible a copy of the previous one. Lastly, these things were got together and arranged in a special switchboard (shown on the screen), so that at a moment's notice any interrupter could be used, and the results compared. It may also be noted here that for comparison it was necessary that we could as far as possible vary any one factor, and keep the others constant. For example, the number of vibrations could be increased, the volts could be decreased, and the ampères of current increased, or the voltage increased and the ampères reduced. The following facts in the experiments were carefully noted: Firstly, the change in the *ampère meter;* secondly, the alterations in the *spark;* thirdly, the difference in the *Crookes' tube;* fourthly, the results of photography; and, lastly, the condition of the screen as tested by the appearance of the shadows in the actinometer. For example, as we increased the number of vibrations per second, keeping the current constant, the number of ampères fell. On the other hand, as we decreased the number of vibrations per second, the current passing to the primary coil as registered on the ampère meter steadily increased. Again, as the sparks became more rapid, they became thinner; as they became less rapid, they became thicker. As the current increased, the brilliancy of the tube increased, the photographic action was quicker, the brilliancy of the fluorescent screen was greater, and its power to read the numbers in the actinometer was also increased. In the same way variations could be obtained by altering the voltage, while the number of vibrations per second and the current remained constant, and again the result could be varied by altering the current and keeping the voltage and number of vibrations constant. Here we come to a difficulty, because it will immediately be seen that we cannot alter one of these factors without changing one or more of the others. It was quite clear that the number of vibrations per second was of less importance than the volts of current or the ampères of current, especially when these were properly utilized in the interrupter by suitable mechanical or electrical arrangement for giving the full charge to the primary coil, or, in other words, complete contact with a very sudden break.

Having thus determined upon the factors necessary, the question of the best form of apparatus was carefully considered, and the principles involved were the construction of a machine which would give whatever variations were required in the number of contacts and breaks in a given space of time; secondly, a sufficient period of contact to get the amount of current which would give the maximum charge to the primary coil short of injuring it; and thirdly, an extremely rapid break. With this view, Mr. Apps constructed a special interrupter, which is here described. Briefly stated, the interruptions are made in the primary circuit of the coil, but the number per second is regulated by means of an electromotor, worked upon an independent circuit. An upright bar, hinged at the bottom, is moved backwards and forwards by means of a horizontal bar, whose length may be varied by means of an excentric. At the top two platinum points are placed, one on each side. These are

caused to pass through a given space from right to left by the revolution of a wheel, and they come in contact with the two lateral parts, upon each of which a screw is placed tipped with platinum. One revolution of the wheel, therefore, means two contacts. It will be noted here that by the screw arrangement, the space through which the upright arm passes in air may be limited or increased. This gives us a measurement of the actual duration in time during which the primary current is passing into the coil, a very valuable extra factor in a successive series of experiments. It will be further noted that in this special interrupter we can vary the vibrations per second in a given time, and record the number; we can increase the rapidity of the break; we can vary the rapidity of the break; we can vary the time the points are in contact, and not only so, but the factors in each case can be definitely determined over a series of experiments for comparison. As a matter of selection, therefore, I have chosen this instrument, but am prepared to admit, and would here repeat as already stated, that to a certain extent this arrangement can be got by other means, but not in the same definite way. The mercurial interrupter is often deficient in the last detail, viz., an arrangement for proper saturation of the primary coil before the break is made; but in some forms, particularly those in which the upright rod can be varied in length, so that the distance it dips into the mercury may be varied to a certain extent, the same saturation of the primary coil may be obtained. The movement of the surface of the mercury is, however, against the same definite and correct measurement. Moreover, the changes which rapidly take place from oxidation and other conditions considerably interfere with the results.

Lastly, we come to the rotating form as figured in Morton's book (picture put upon screen), and here we have many of these advantages referred to above. It will be seen that with it we can get a definite number of vibrations in a given time. We can also vary the rapidity of the break, but the size of the insulating discs remaining constant, we have not the means of varying the actual time of contact, as we have by means of the studs in the interrupter made for me by Mr. Apps. If different wheels with different sized insulated discs could be inserted, then we might have an approximate adjustment, or if an insulator could be made in the form of a cone, with a sliding bar for making contact, then some such adjustment might be obtained. We have already indicated the difficulties, and we will conclude by referring to another of these.

From what has been said, it will be evident that for a given piece of work we can get the best results by a selection and proper arrangement of the number of the makes and breaks per second, the duration of the contact, and the suddenness of the break. The difficulty to which I refer is easily seen. Whether it be in the special Apps interrupter, or in the mercury form, or the rotatory form as used in America, it will be seen that, while we can increase the number of contacts per second (and with this the suddenness of the break), increased rapidity means diminished time in contact. We cannot make the wheel revolve quicker without causing the arm to vibrate more quickly, and so diminish the time the points are in contact, so while we increase the number of breaks per second and the intensity, we lose in the deficient supply of the current to the primary coil, as the contact is not sufficiently long to saturate it. This is the point at which I have arrived, and possibly it may in the future be altered. Some will say that just as we get the best results in the interrupter by wise selection and combination of its best points, so we can only hope to obtain the maximum results by selecting and combining all these different parts of the apparatus, particularly the tube and the coil, but that does not come under the scope of our paper. The question before us is the best interrupter as a factor in a number producing a certain result. As a result of a large series of experiments, therefore, I have come to the conclusion that the skilled operator will often get results with a comparatively simple form of interrupter. Secondly, for ordinary work in a good operator's hands little more than this is needed. Thirdly, that for special work, especially in the deep-seated structures of the body, where we desire great penetration for photography or fluorescent screen, a special form such as we have suggested may be found suitable by reason of the variations described. Fourthly, that no one particular form will possibly be used exclusive to all the others. Lastly, that a perfect interrupter has not yet been devised.

In the discussion which followed, Lord BLYTHSWOOD said he had devised a machine with cam motion, so as to get varying times of contact. He did not, however, find it efficient, though he could give no reason for its failure. He had obtained some of his best results with his large influence machine of 180 plates.

Mr. MACKENZIE DAVIDSON said the Society was greatly indebted to Dr. Macintyre for his paper. He would like to ask him if he had succeeded in photographing the deep-seated structures which he had succeeded in viewing on the fluorescent screen.

Mr. PAYNE said he had made many contact breakers, most of his being mercury breaks. He wished to ask Dr. Macintyre whether he found the direction of the current made a difference in the efficiency of the contact breaker. Mr. Payne had found with his mercury breaks that a contact of six or eight fine rods was better than that of one large bar. He also found these had a limit of speed, beyond which a contact breaker was not efficient; thus, a double break he had made would not work well beyond 700 breaks per minute. He had also tried a rotary contact with four or five notches in it. This he found disturbed the mercury very little, and in that respect seemed more satisfactory than others he had tried.

Mr. SWINTON said he had tried a rotary contact break consisting of a drum, to which were affixed triangular pieces of metal, so as to vary the time of flow. He could not say, however, that it had proved very satisfactory.

Mr. APPS said he had made a contact breaker about twenty years ago, which gave an exceedingly short break. He came to the conclusion then that it was possible to break contact too suddenly; he believed that by a proper adjustment of spring and size of hammer, the spring contact breaker would be found to be best for general purposes. Mr. Apps disclaimed the credit Dr. Macintyre had given him for the new mechanical break, for he said it had been constructed largely to Dr. Macintyre's own designs.

Mr. H. G. MADAN said he had an Apps' coil about thirty years old. He could, therefore, confirm all that had been said about the durability of this make of coil. As to mercury breaks he had always found them unsatisfactory. He thought the spring contact breaker was the most generally useful, though he believed the Vril was a distinct improvement in its form. He asked if any better metal than platinum could be found for points of contact.

Mr. GIFFORD said he had tried the mercury break a good deal. He had used various liquids to cover the mercury: such as paraffin-oil, methylated spirit, etc., but he found the best was "Burgoyne's Absolute Alcohol." He had always found a "fuzziness" in his photos when he used a mercury break. He had also tried a break in which he substituted a weight instead of the spring, but he did not feel satisfied that it was an improvement.

Mr. WILSON NOBLE suggested the use of liquid phenol or liquid carbolic acid to cover the mercury.

Dr. WALSH congratulated Dr. Macintyre on having seen the ventricles and convolutions of the brain. He reminded members that some time ago Mr. Webster had claimed to have photographed some of the membranes of the brain—he believed the falx cerebri, and falx cerebelli.

Mr. CONRAD COOKE said he had found that the best way to provide against the wear at the platinum points of contact breaker was to solder in with tin solid rods of platinum, which could be pushed through as they burnt away,

The PRESIDENT said he felt sure the members would agree with him that they were greatly indebted to Dr. Macintyre for his paper. Reference had been made to the Deprez contact breaker. He had tried it among others, but he found it so noisy that it could not be used with any degree of comfort. He had also found that revolving breaks were not satisfactory. He advocated the use of breaks driven independently of the coil, for by that means a more regular action was obtained between the flow from the primary and the secondary. He did not agree with Mr. Apps that it was possible to break contact too quickly; what was wanted was an arrangement by which the spark between the points could be rapidly extinguished, and this could be done by establishing a blowing action in a transverse magnetic field. The President agreed with Mr. Apps and Dr. Macintyre as to there being a critical period beyond which an increase of speed in the contact breaker would be useless. Every coil had a time-constant of its own, and to try and work it beyond that would bring no advantage. If the coil were required to be worked more rapidly, it could be done by decreasing the condenser. Mr. Madan had asked if any metal other than platinum could be used at the contact points. Nickel would do very well, but it needed filing at very short intervals to keep the wear regular; so far, he knew of nothing better than platinum. He also congratulated Dr. Macintyre on having seen an individual's brains.

Dr. MACINTYRE replied. In answer to Mr. Mackenzie Davidson, he had not had time so far to do much photography of the deeper structures. He had been obliged to confine himself to screen-work. He had found that a mixture of 7 mercury to 1 platinum had given

best results with his mercury break. He had not tried oil at the top, as suggested by Mr. Swinton, nor had he used carbolic acid: he so far preferred alcohol. In reference to Dr. Walsh's remarks, he had seen the harder structures of the brain well defined, and he found the best way to see them was to begin with the tube gently, and gradually work it up to the best state of efficiency. He suggested that, in looking at the brain, the soft tissues should be first looked for. What he was anxious to do was to photograph the denser brain: the ventricles were less dense. He thought the transverse magnetic field suggested by the President was well worthy of trial. He thanked the members for the reception given to his paper.

RESEARCHES ON THE POSSIBILITY OF THE POLARIZATION OF ROENTGEN RAYS.

By L. GRAETZ.

(TRANSLATED FROM *Wiedemann's Annalen*, No. 6, 1898.)

THE theoretical importance of the question whether Roentgen rays can be polarized has caused a number of physicists besides Roentgen himself to make experiments in this direction, which have, however, given no certain positive results. The researches were carried out according to two methods. The *first* method was that which it is usual to apply to ordinary light, in which the brightness of an image formed by rays that have passed through two plates of tourmaline or other crystal is compared either by photography or with a fluorescent screen, the axes of the crystals being parallel or crossed, according as they are to transmit or cut off the rays. The most extended and accurate experiments in this direction were carried out by Professor S. P. Thompson,* in which he cut from each crystal under observation three pieces of equal thickness, two of which, so placed that their axes were at right angles to one another, were laid side by side over the third. In this way he was able to observe them at the same time in parallel and crossed positions, using the same total thickness of crystal. The research was extended to include andalusite, mica, calcspar, nickel sulphate, nickel ammonium sulphate, potassium cobalt sulphate, ammonium cobalt sulphate, cobalt fluosilicate, and nickel fluosilicate. All gave throughout negative results, so that Thompson pronounced an opinion opposite to that of Galitzine,† who claimed to have perceived a difference in the case of tourmaline, and characterized the phenomenon as an "X ray myth."

The *second* existing method consists in observing whether one and the same crystal plate exhibits a varying absorption of rays when placed in different positions, and therefore a dichroism of a kind not relating to the colour, but to the intensity of the transmitted light.

Similar, and certainly negative, experiments were described by Roentgen in his first work; and in his latest communication* he stated that he had vainly tried plates of calcspar, quartz, tourmaline, beryl, arragonite, apatite, and baryta. Doelter has made similar experiments,† but he, on the contrary, believes that he has found distinct differences in the behaviour of some substances, namely, andalusite, arragonite, and possibly in quartz. Since even in andalusite Roentgen found negative results, it appears that Doelter's observations are still uncertain.

Both methods have this in common, that the Roentgen rays are assumed initially to be unpolarized on their formation, and to undergo double refraction, and therefore polarization and varying absorption, in their transmission through the crystal.

Now, since, speaking generally, refraction of the rays has in no case been observed with certainty, the anticipation that a definite double refraction and difference in absorption would be found is based on slender grounds, and, in fact, is not realized.

There is, however, a *third* method which can be adopted to investigate the production of polarization, viz., by setting up *such conditions that the rays are produced polarized from the first.* The closest conception that can be formed of the new rays is, indeed, that they are originally excited by some sort of vibrations—presumably those of exceptionally great frequency—of the particles of the anticathode, so that they are a special kind of fluorescence or phosphorescence. This fundamental idea, for which, however, no strict proof exists, is found more or less sharply expressed in most discussions.

If this view is justified, one would expect that it would be possible to produce Roentgen rays with partial polarization, not, however, when they are emitted from the surface of amorphous substances, such as metals, glass, etc., *but when they are emitted from those of crystals.*

* *Philosophical Magazine*, vol. xlii., p. 162, 1896.
† *Mémoires de St. Pétersbourg*, April, 1896.

* *Sitzungsberichte der k. Akad. der Wissenschaften zu Berlin*, 1897, p. 407, and *Wiedemann's Annalen*, vol. lxiv., p. 11, 1898.
† *Neues Jahrbuch für Mineralogie*, etc., vol. ii., p. 100, 1897.

According to the comprehensive researches of Sohncke* upon polarized fluorescence, the fluorescence of all crystals which can be made to fluoresce at all is always polarized ; that is to say, the particles of a crystal produce vibrations not in all possible directions, but in a certain fixed direction determined by the structure of the crystal. The phosphorescent light proceeding from crystals exhibits the same properties† for the same reason.

If, therefore, Roentgen rays are excited by allowing cathode rays to fall upon any non-isotropic crystal placed in their path, it is to be expected, in case the assumed analogy holds good, that rays more or less polarized will in this way be emitted from the vacuum tube. Should the polarization produced by this means be still small in amount, it ought, at all events, to be strong compared with that produced by double refraction; and it appears possible that polarized rays of this kind should reveal themselves by exhibiting a varying absorption in crystal plates.

In order to test this, I have prepared a number of Crookes' tubes, in which crystals have been fixed. The crystals and electrodes were disposed in each tube, so that either or both electrodes could be used as cathode, and so that both those rays which proceeded directly from the bombarded surface, and those which had to first traverse the whole thickness of the crystal before they came out, could be observed. Crystals of calcspar, tourmaline, andalusite, and dichroite were used. The three last crystals, namely, a tourmaline from Gjörestadt in Norway, an andalusite from the Lisenzer Alp in the Tyrol, and a cordierite (dichroite) from Haddam in Connecticut, all pieces of finest quality, were placed at my disposal in the most friendly manner by Professor P. Groth. The colour of the phosphorescence of calcspar under the influence of cathode rays is, as is well known, red. The other three crystals do not visibly phosphoresce, although they emit intense Roentgen rays. Now, in the case of the tourmaline a single, intense red, luminous spot made itself visible in the surface directly bombarded by the cathode rays, and was equally marked if the cathode rays fell upon a prismatic face as when they fell upon a basal face. This red, luminous spot, having no fixed relation to the axes, has exactly the appearance of the red-hot, glowing spot upon metal anticathodes, and is probably also a phenomenon of incandescence.

* *Wiedemann's Annalen*, vol. lviiii., p. 452, 1896.
† G. C. Schmidt, *Wied. Ann.*, vol. lx., p. 754, 1897.

The electrodes were plane, since it was sought to excite the greatest possible amount of surface of the crystal. The tubes remained on the pump during the research, and the exhaustion was carried by degrees so high that at last no discharge was possible. With a spark-length of 50-70 millimetres, the rays were so intense that the whole of the bones of the hand could be seen on the fluorescent screen. But an illumination as bright as that due to a metal anticathode was never produced.

Now, if the rays proceeding chiefly from the tourmaline were partially polarized, a single tourmaline plate outside the tube would serve as an analyzer. Any difference in the transparency would, however, be augmented if one used a tourmaline pincette as analyzer. The rays were so powerful that, after passing through the two tourmaline plates, they gave on the fluorescent screen a bright spot, surrounded by the circular shadow of the metal frame. Observations with calcspar in the tube appeared at first to give positive results. When the eyes were sufficiently accustomed to the darkness to recognise small differences in brightness, the position of greatest darkness, on rotating the tourmaline, always appeared, in several experiments, to be given in the same relative position of the tourmalines, which position, moreover, did not quite correspond with the position of greatest optical darkness. An observation with a Nicol's prism, instead of the tourmaline, showed no differences. The images produced by the rays, after traversing the tourmaline pincette, were then photographed with a constant duration of exposure; but these exhibited also no perceptible difference corresponding with the different positions of the tourmalines. The positive result previously found appears therefore to be questionable; and, in fact, repetition of observations of the transparency certainly often gave minima of brightness, but not for one and the same position of the tourmaline plate. The reason for this was finally found in the properties of the fluorescent screen. This consisted of barium platinocyanide in small crystals, and this substance is itself dichroic.

For this reason the image was more or less bright, according to the position of the eye. On account of the smallness of the area which the picture of the aperture of the tourmaline pincette covered, it was very difficult to view it always in the same direction or by means of the same patch of the crystalline surface.

With the large image that the Nicol's prism gave the mean brightness of a large portion of the crystal came

into consideration. After these causes of error were removed, by fixing so far as possible the positions of the eye and of the tourmalines, neither calcspar nor any of the other crystals yielded any signs of polarization. Hence not even by this method—the most powerful, in my opinion, of those hitherto applied—is there produced any polarization of the Roentgen rays; so that the longitudinal nature of these rays still remains an open possibility, if, indeed, we are here dealing with waves at all.

PHYSICAL INSTITUTE OF THE UNIVERSITY OF MÜNCHEN,
March, 1898.

REMARKS ON THE PRECEDING PAPER BY PROFESSOR SILVANUS P. THOMPSON.

THE observations of Dr. Graetz furnish additional confirmation of the view I have entertained, since I made the experiments alluded to, of the non-existence in the Roentgen rays of the possibility of polarization. It should be remembered that Galitzine, whose method depended upon a particular way of intensifying his photographic prints, used tourmalines. Now, the tourmaline does not contain amongst its constituent atoms any of the elements of high atomic weight. It would seem, therefore, *a priori* unlikely that it should have much *difference* of absorption for the Roentgen rays assumed to vibrate parallel and transversely respectively to its axis, since, to begin with, its absorption is small for all Roentgen rays, however they vibrate. It was for this reason that, in my experiments, I tried to find dichroic bodies, known to polarize ordinary light, having some heavy-atom constituent.

The matter does not, however, rest upon the authority of a single physicist. The late Professor Alfred M. Mayer was a refined and able experimenter. He tried with tourmalines and with herapathite (iodosulphate of quinine), the latter being more strongly dichroic than either tourmaline or andalusite, and he found no result. M. Henri Becquerel, whose experimental skill none can doubt, tried with tourmalines, and equally failed to detect any trace of polarization. M. Sagnac has essayed a number of dichroic substances, and has in every instance attained negative results only.

A phenomenon which cannot be reobserved under the most favourable circumstances by many experimenters of adequate skill, keen to discover and substantiate it if it exists, cannot be accepted on the unverified observations of an isolated observer, however eminent. And now that Dr. Graetz has added a third method of observation, and finds also no trace of the alleged phenomenon, it may be taken as established that Roentgen rays are incapable of being polarized by transmission through tourmaline. The question of their transverse nature, which such a phenomenon, if confirmed, would have established, remains still undetermined. But, though we may take it that the alleged polarization by tourmaline has been sufficiently disproved, it must be remembered that, in the philosophy of science, no amount of negatives will preclude or disprove a real positive. It is quite conceivable, though now very improbable, that some dichroic crystalline body may be discovered which *will* produce a polarization of the Roentgen rays; but if it does so, effecting its purpose by absorption and double refraction, as tourmaline does upon ordinary light, it is clear that it will be a body which will refract as well as absorb. The only open chance of finding such a substance lies in the examination of those substances which contain in the molecule some constituent of high atomic weight; and even in this case the probabilities are greatly adverse.

Incidentally, I would remark that the red spot which Dr. Graetz noticed upon the surface of some of his crystals, and which he regards as a phenomenon of incandescence, is due, almost beyond question, to the presence of sodium compounds—probably a trace of common salt from the fingers of the person who handled the crystals while mounting them. If examined with the spectroscope, it would almost certainly show a sodium spectrum. I have frequently observed these spots, and have found them due to the luminescence of sodium compounds.

THE ACTION OF ROENTGEN RAYS UPON THE GROWTH AND ACTIVITY OF BACTERIA AND MICRO-ORGANISMS.

A PRELIMINARY NOTE.

By R. NORRIS WOLFENDEN, M.D., and F. W. FORBES-ROSS, M.D.

(*Read at the Meeting of the Roentgen Society, June* 7, 1898.)

SOME work has been done upon this subject, but it has not led to any definite conclusions; and in view of the somewhat conflicting statements published, the authors

have thought that further investigations would be desirable.

With this end in view, they have selected as the first subject for experiment the *Bacillus prodigiosus*. Six culture tubes of the normal growth on potato were obtained from University College Laboratory, and on May 25 these were set to incubate in a Hearson incubator, at a temperature of 35° C., in the dark.

After five days' growth a tube was taken, and from it two fresh cultures were made, one as a simple control culture, and the other was rayed along with the mother culture for an hour.

After twenty-four hours' growth, that in the tubes which had been rayed (*i.e.*, the mother and one of the daughter cultures) had increased markedly in comparison with the original tubes, which had now been growing for six days. The control culture appeared to be only just showing a margin of increase. The difference in growth between the two tubes which had been rayed and the non-rayed control tube was very great, showing that undoubtedly the action of the X ray tube had been exceedingly stimulative.

In order to determine whether the exposure of the potato to prolonged X ray action would produce such changes in the medium of growth as to account for any marked increase of bacillary growth, two sterile tubes were rayed for one hour; a culture was then made on one of them from one of the previous tubes which had been rayed, and showed active growth, and another culture was made in the second tube from a culture which had never been rayed at all. These were incubated under precisely the same conditions as the previous tubes. When examined two days afterwards, the growth in the rayed potato cultured from rayed bacilli had entirely outgrown the culture on rayed potato from non-rayed bacilli, therefore the only cause of this phenomenal growth must have been a property of the bacilli themselves, and not of the medium of growth.

Cultures up to the fifth generation were made, and the following facts were arrived at:

A single exposure to the X ray increased growth markedly, and along with it there was an increase of chromogenetic property, even though grown in the warmth. As is well known, *Bacillus prodigiosus* does not form pigment when grown in a warm atmosphere.

Further exposure to the rays so stimulates the growth as to deprive the bacilli of power of this peculiar pigment formation in the warmth for the time being, though th property is afterwards recovered to such an extent th the amount of pigmentation, though slightly different colour, is in excess of the original culture.

Up to the fifth generation, the result of exposure an hour to X rays of the culture is to produce exuberant growth; apparently the pigment power somewhat altered.

The method of application of the X rays was follows: With a large 18-inch spark coil of Newto make, a power was used of 16 volts, and 8 to 10 ampè The focus-tube was placed about 6 inches above the t tube containing the potato growth. In every instance exposure was of fifty to sixty minutes' duration, v occasional resting of the tubes, which were run v the anodes as nearly red-hot as practicable.

The authors do not here attempt to enter into explanation of these phenomena of growth. They content to record the facts that exposure of the *Baci prodigiosus* to the radiations of a focus-tube induces marked increase of growth, and peculiar changes in pigment-forming powers of this particular micro-organ

They will merely add that in some of the lower fo of vegetable life the same changes are observed, not in the *protococcus*. An exposure of this organism X rays for five to ten minutes appears to much stimu its activity; and if the exposure is a little prolonged cells become much paler, the chlorophyll disapp and the protoplasmic contents are more granular. cells recover their green colour when exposed to light, but on again exposing to X rays, the chloro seems to disappear more or less completely.

The culture tubes of *Bacillus prodigiosus*, which been the subject of experiments mentioned in this are shown here, as are microscopic specimens.

The following microscopic changes are noticed a result of exposure of these *Bacilli* to X radiations:

There is apparently little to call for notice as re the relative size of the rayed and non-rayed bacilli

As regards grouping, it will be noted that an un property of *Bacillus prodigiosus* is shown—that is, g in chains or strepto-bacteriæ; and, further, wha present giving rise to controversy, spore form which seems to be clearly established in the growth here shown. For the rest, the bacilli ap both cases equally granular, and stain equally ends, and as irregularly.

* * * *

The authors are continuing these experiments, especially upon the pathogenic bacilli, among which it is possible that changes in growth may be accompanied with some alterations in the character of the bacilli.

THE ROENTGEN SOCIETY.

A MEETING was held on June 7 at 11, Chandos Street. The President, Professor SILVANUS P. THOMPSON, F.R.S., in the chair.

The two following papers were read:

A PINHOLE ROENTGEN RAY CAMERA AND ITS APPLICATIONS.

By A. A. CAMPBELL SWINTON.

SEEING that, so far as is known, the Roentgen rays are incapable of refraction, it is impossible to deal with them by means of a lens. For use with ordinary light, however, as is well known, a photographic camera need not necessarily be fitted with a lens —a simple pinhole can be substituted, and very fairly distinct images of surrounding objects can still be thrown on the ground glass, and satisfactorily photographed by sufficiently long exposure. Now, with the Roentgen rays, a pinhole acts in producing images just as it does with ordinary light, in fact, perhaps even more advantageously, for the reason that, with the Roentgen rays, there is no diffraction to interfere with the effect.

The writer has therefore designed a pinhole camera for use with the Roentgen rays, and with it has obtained some interesting results. As will be seen from the sectional illustration, it is a very simple piece of apparatus (see Fig. 1). A is the pinhole in a lead disc, held in place by a small brass cap, and made removable, so that pinholes of different diameters can readily be substituted one for another; B is the body of the camera, made of sheet brass, thickly lined with lead, C, to render it opaque to the Roentgen rays; D is a wooden framework into which slides either the fluorescent screen E, which takes the place of the focussing ground-glass of an ordinary photographic camera, or a holder for a photographic plate in a black paper envelope; F is the eyepiece of an observation tube, for use with the fluorescent screen. It is of opaque paper, so as to exclude the light, and is insulating, so as to preclude danger of electric shocks, a matter of some importance, seeing that the pinhole may be placed in very close proximity to a highly electrified tube, and even a very slight shock in the face is unpleasant. Now, of course, in the case of ordinary light, bodies may be either self-luminous or may shine with light borrowed from another source, which they reflect. The sun is an instance of the first class, the moon of the second. In ordinary photography it is with objects of the second class—that is to say, with bodies that are not self-luminous, but are seen only by reflected light—that one has chiefly to deal. With the pinhole Roentgen ray camera, on the other hand, so far as the writer's experiments go, it is only objects that are themselves emitting Roentgen rays that can be seen on the fluorescent screen or photographed. As the Roentgen rays are supposed to be reflected in a diffuse manner to an appreciable extent, it would seem that this should not theoretically be the case; but though the writer has made repeated attempts with exposures lasting as long as thirty minutes, and with the most intense Roentgen rays that he could produce, he has been unable to obtain the slightest trace of an image of various metallic objects placed in close proximity to a focus tube. Consequently, if Roentgen rays are in reality reflected at all, they are so to but an exceedingly small extent.

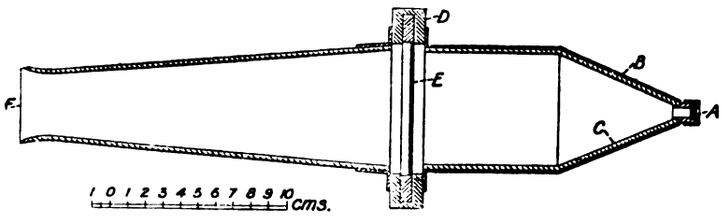


FIG. 1.

Possibly in the future, when more intense Roentgen rays can be obtained, the result may be different, when the pinhole camera will render possible the photographing of objects by reflected Roentgen rays. No doubt such photographs would be very interesting, and would cause things to look very different to what they appear, either by ordinary reflected light, or by transmitted Roentgen rays.

As it is, however, when the pinhole camera is turned so as to point at a body emitting Roentgen rays—as, for instance, the anticathode of a focus tube—interesting results are obtainable. There is no need for very prolonged exposure in order to produce a clearly-defined image of just that part of the anticathode from which

the rays are proceeding; indeed, this can be seen quite clearly on the fluorescent screen.

If the distance from the anticathode of the tube to the pinhole is made equal to the distance from the pinhole to the fluorescent screen, the image will be just full size. If the former distance be reduced or the latter increased, the image will be correspondingly magnified, or *vice versâ*.

Mr. Mackenzie Davidson has already pointed out the importance for sharp radiography of using tubes in which the active anticathode area is as small as possible. The pinhole camera makes it easy to compare one tube with another in this respect; indeed, to measure accurately the dimensions of their active areas and note their exact locality and form.

The writer has tested many tubes in this manner, and has also made experiments with a special double adjustable tube, in which both cathode and anticathode could be moved independently towards and away from one another through considerable distances. The cathode of this tube was about 3 centimetres diameter and about 2 centimetres radius of curvature. When the anticathode was so placed as to intersect the cathode stream just at the focus of the stream, the active area was only a little more than 1 millimetre in diameter; and with a distance of 4 centimetres between cathode and anticathode, when the latter was little beyond the focus, the active area was found to be almost exactly 1·5 millimetres diameter. As the anticathode was gradually moved further away from the cathode, the active area became larger and larger, till, with a distance of 14 centimetres, the active area had grown to considerably over 2 centimetres in diameter. Further, as the active area grew in size, it ceased to be of uniform brightness, but gradually resolved itself into an intense central nucleus surrounded by a less bright halo. In some cases the halo consisted of one or more distinct hollow rings, concentric with the nucleus and with one another.

The size of the total active anticathode area was found to some extent to depend upon the degree to which the tube was exhausted, but this was only the case when the anticathode was placed so as to intersect the cathode stream considerably beyond the focus. In the neighbourhood of the focus its dimensions were always about the same, and were not affected by the position of the cathode relatively to the glass walls of the tube.

It was further found that the cathodes that were not of true curvature, or had rough surfaces, gave irregular-shaped active areas, while accurately made and well-polished cathodes gave active areas which were eclipses.

These experiments clearly indicate the reason some focus-tubes give such much better definition others. For the sharpest definition the active ought, of course, to be a mathematical point havir dimensions, but only position. This can be most n approximated to by making the cathode of true sp cally concave curvature with a well-polished surface by so placing the anticathode that it intersects cathode stream as nearly as possible at the focu must be remembered, however, that, owing probal the mutual repulsion of the cathode rays, the foc always beyond the centre of curvature of the catho an extent which appears to vary with the deg curvature, the vacuum, and the applied E.M.F. variations are, however, small, and with cathodes 3 centimetres diameter and 2 centimetres radi curvature, a distance of from 3 to 4 centimetres be cathode and anticathode will be found about righ may be mentioned that in most tubes in the mark definition is defective owing to the distance bei long.

With the form of adjustable tube designed writer, in which the cathode is made movable, be found that, provided the tube is so shape the required range of resistance can be obtai moving the cathode not more than 1 centimet amount of variation in distance between catho anticathode will not appreciably affect the sharp definition obtained, if the arrangement is suc when the cathode is at the end of its travel to the anticathode, the latter intersects the stream just at the focus. The above results, h show the reason why the other form of adjustal designed by the writer, in which the anticathode movable, is not to be recommended, for the rea with this form of tube a considerable movemen anticathode is necessary, and it is, therefore, not to obtain a sufficient range of adjustment witho fering with the definition, a fact which the wr already noted in his previous paper, and the which is now clear.

In conclusion, there seems little doubt that if would test their tubes with a pinhole camera, s above described, it would quickly lead to a con improvement in the definition of the tubes t supply.

Such testing can be effected while the tube is on the pump, and taking, as it does, only a few seconds, is well worth the trouble.

The writer is much indebted to Mr. J. C. M. Stanton, who constructed the pinhole camera, and to Mr. H. T. Wolff, who made most of the tubes experimented on.

WORK ON THE ROENTGEN RAYS.

By T. C. PORTER (Eton College).

THIS paper is a summary of experiments and results made and obtained by the writer at Eton, and published in the magazine *Nature*, at the dates to be found at the end of each section of the paper. They are here collected at the kind request of Professor Silvanus Thompson, who has also done the writer the honour of inviting him to read the paper before the Roentgen Society.

I. When a tube emitting the X rays—*i.e.*, those to which flesh is almost transparent, but bone opaque—is heated, the character of the rays seems to change, for when the shadow of the hand cast by them on a fluorescent screen is observed, the flesh seems as opaque to the radiation as the bone; but, since the effect may possibly be due to the decrease of illumination of the screen as a whole—for the whole screen is much more faintly illuminated when *these* rays are being emitted than during the emission of the ordinary rays—it is necessary to find some proof positive that the darkening of the shadow of the flesh is not merely a subjective phenomenon.

The following experiment constitutes the first proof of the non-homogeneity of the Roentgen radiations, though the different appearances of the shadow of a hand on a screen had been noticed earlier, *e.g.*, by Silvanus Thompson (*Comptes Rendus*, April, 1896):

A "Roentgen" whole plate was wrapped in two thicknesses of the black paper generally used for the purpose, and supplied with the plate by the Sandell Plate Company, and brought in darkness into the room for experiment, lit dimly by a single candle at some distance from the place where the plate was to lie. The plate was then laid film uppermost (still, of course, wrapped in the black paper) 6 inches below the exhausted tube (the latter placed in the usual position). A piece of plate-glass, $\frac{1}{3}$ inch thick, was then laid over half of it, and a left hand laid on the other half, together with a piece of a small aluminium tray, and exposure was then made for one minute, with the exhausted tube *cold* (15° C.). The paper over the exposed half was then marked for the purpose of recognition; this half was then covered with the glass, to protect it from any further action, and the photographic plate turned in its own plane through 180° about a vertical axis, to enable the operator to place the same hand on the other half of the plate in exactly the same way as at first. The tube was then heated with a spirit-lamp giving a large flame for about forty-five seconds, when, the left hand being kept in position, the current was switched on for one minute; at the end of this time, the appearance of the discharge in the tube showing that it was growing cold, the current was switched off, the spirit-lamp again applied to the tube with the right hand, the operator's left hand being still kept rigidly in position over the plate, then the current applied again for one minute, and so on, the spirit-lamp and current alternately, till six and a half minutes' exposure had been given (the current at its final application ran for a minute and a half). The plate was then removed, and developed uncut with a hydroquinone developer, with the result that whilst the far denser background of the last-exposed half of the plate showed that it had received by far the greater amount of radiant energy from the heated tube during its six and a half minutes' exposure, only the very faintest traces of the bone-shadow could be made out in the very bold shadow of the flesh of the fingers; whilst on the other half, which had received but one minute's expose to the cold tube, images of the bones were very clearly visible. This experiment shows that the radiation received from the hot tube resembles the rays hitherto called X rays (which I have called X1), in being able to pass through paper opaque to ordinary light, but differ from them in being unable to penetrate flesh. These last rays I have ventured to call X2. (June 4, 1896)

NOTE.—Since the effect of heating the tube is to lower the degree of vacuum, it is natural that these X2 rays should be the first to be emitted, as the tube is gradually exhausted.

The aluminium tray mentioned above proved almost opaque to the X2 rays. One would naturally conjecture that if the X radiation be of an undulatory nature, the wave-length of the X2 rays is nearer to the wave-lengths of ordinary light, since the opacity of bodies to these rays more closely resembles their opacity to ordinary light; and since recent research makes it likely that the

waves of the X radiations are very much shorter than the latter, then in the X2 rays we have the longest waves of the X radiation.

Some distinguished physicists have supposed that the X radiations are a-periodic: does not the emission of rays of continuously varying quality, judged by their penetrative power, make it more probable that the waves (if the rays are such) emitted in any one state of the tube have a definite period, or a definite average period, which varies *pari passu* with the variation in the state of the tube?

II. The effect of cooling the tube was next studied, using ether and solid carbon dioxide, first together, and, since this seemed to stop the emission of rays by its electrically conductive power, apart from its low temperature, afterwards, solid carbon dioxide alone. In both cases the fluorescence of both tube and screen very rapidly died out, the current apparently failing utterly to pass through the tube; but as it grew gradually warmer again, the fluorescence in it returned, not gradually but very suddenly, at a temperature not very far below that of the room, the glass lighting up brilliantly, and the shadows of the bones showing on the screen with increasing distinctness, the emission of X rays reaching a maximum at about 12° C. On further heating, X2 rays began to be evolved, the fluorescence of the screen growing brighter for some little time, till the tube reached the state described already.

[NOTE ADDED LATER.—It would seem, therefore, that cooling a tube stops the emission of the rays by greatly increasing the resistance of the tube; and at first one might attribute this to the condensation of some of its contents. This explanation, however simple, does not seem to the writer to account for the facts, for the contents of the tube are particles of air, practically free from moisture, from the very way in which the tubes are filled, and air could scarcely be condensed by solid CO_2, which is itself at a temperature certainly not below 100° C., and did not, in these experiments, cool the tube to any temperature near this; nor are the gases which are occluded by the electrodes supposed to be any which are easily condensed. The writer can only suppose that the effect is to increase the condenser-like action of the inner and outer walls of the tube (an account of which is given later) by diminishing the motion of the particles composing the inner surface of the tube, and thus making it more difficult for the molecules of residual gas to escape the attraction to the side of the tube. Of course, if there is any considerable quantity of water-vap present, or if the presence of a minute quantity of ei water-vapour or of any other easily-condensible ga necessary for the conduction or convection of the cur the condensation of the minute quantity of this vap whatever it may be, would amply explain the grea crease in the resistance of the tube when cooled.]

About this time (the early summer of 1896) n contradictory statements were published respecting action of X ray tubes and their radiations on insul conductors, both charged and uncharged, and als the vane of a Crookes' radiometer; to decide w were true, was the object of the next series of ex ments.

A well-insulated brass plate was connected with c the pairs of quadrants of a standard Thompson (K electrometer, the distance from mirror to scale 15 feet; the other two quadrants were earthed soldered connection with the water and gas pipes c building. Earthed in a like manner was the aluminium plate, $\frac{1}{30}$ inch thick, used to screen t sulated plate, not only from all electro-static actio also from the effects of the "electric wind" blow times from the tube. The result was that the X failed to charge the insulated and uncharged whilst they completely discharged it, if it wer charged, and that, too, either +vely or −vely. the insulated plate was *un*screened, the X ra partly discharged it, if the plate were strongly charged to begin with; and if at starting it were s − vely charged, the radiation of the tube first disc it, more rapidly than in the first case, and then c it +vely, so that it was finally left with a +ve ch the same magnitude as that left when the pla +vely charged to begin with. Lastly, if the pla uncharged to start with, the unscreened tube ga +ve charge of the same magnitude as before; a is exactly what one would expect as the combine of the X radiation and the ordinary inductive e the tube. The space outside the tube was at +ve potential, which increased right up to th and was of the same sign all over the bulb part.

With respect to the radiometer, it need only that *when that instrument was properly shielded inductive effects of the tube*, the most powerful X r were without the slightest effect upon it. The seem to act in the same way as the X1 rays to insulated plate, whether charged or uncharge

this I cannot at present feel quite sure. Aluminium seems so far opaque to them that it is doubtful, when a shielding screen is used, whether any of the rays get through; and without a shielding screen one cannot feel certain that the effect observed is due to the X2 rays, either wholly or partly.

After heating an X ray tube and turning on the current, the whole tube is filled with a whitish lavender-coloured light, which comes to a focus on the glass behind the cathode, above or below the level of the latter; and while in this state, giving little or no fluorescence on the screen, the tube does *not* charge an *unscreened* and insulated plate, but it does rather rapidly drain it of a previously-communicated charge, either +ve or −ve. As the tube cools, the lavender light retreats further and further from the cathode, till at last it reaches the upper edge of the rectangular anode, when the +ve charge mentioned before begins to be given to an uncharged, insulated plate, but very slowly. As soon as the centre of the anode is bare of the lavender glow-light, the potential of the unscreened plate very rapidly rises, and by the time the whole anode is clear of the lavender light the normal +ve charge is re-established on the insulated plate. As the lavender glow retires from the cathode, it leaves behind it a space full of almost invisible light, which excites whitish green fluorescence on the glass of the bulb, and it is during this time that the rays are mostly X2, as is shown by the fluorescent screen, and also photographs of a hand. The whole tube, therefore, acts as a fairly good conductor up to the time when the lavender glow crosses the centre of the anode, *i.e.*, the point where the axis of the cathode mirror cuts the anode, when there is an abrupt decrease in conductivity.

This paper now describes the first recorded experiments on the influence of external conductors on the X ray tubes.

III. During some experiments on an X ray tube (Jackson's "focus" form) excited by a 15-inch plate Wimshurst, of the sector and button kind, I noticed that the X1 rays seemed to be emitted or not, according as a brush discharge occurred on the wire leading to the anode of the tube or not; also, that the "electric wind," which blows from the tube, as from all charged bodies, seemed to vary in intensity with the flashes of the X1 rays, the latter being most copiously emitted at the moment when the brush discharge ceased, or the wind moderated. I soon found that by drawing a small "brush" from the wire near the anode, or from various parts of the tube, though not from all—best, from the circular section of the tube in a plane with the edge of the cathode mirror, or in the very immediate neighbourhood of this line—the discharge of X1 rays could be induced at will in a tube which was not otherwise giving them, or only giving a very feeble radiation. Thinking, therefore, that the production of X rays must be in some way connected with the *intermittent* leakage of the charge which resides on the exterior of the tube (the brush discharge has been proved to be intermittent by the aid of a rotating mirror, and a continuous drainage of the external charge stops fluorescence, and the emission of any rays capable of exciting fluorescence on the platinocyanide screen altogether), I tried various ways of drawing off this charge intermittently, with several curious results.

The plan I find works best is as follows: First coat the external part of the tube between the cathode wire loop and the plane of the edge of the cathode mirror with any conducting metallic leaf, being careful that none of it projects beyond the trace of this plane on the glass of the tube. Next coil a stout piece of copper-wire into a circular loop with a stem, and place it over the cathode end of the tube, so that the loop is in the plane of the edge of the cathode, but does not *touch* either the glass of the tube or the metallic coating—an interval of about $\frac{1}{20}$ inch answers excellently with my tubes—and lastly, bring the stem of the looped wire, or, better still, a more pliable piece of wire connected with the loop stem, within a very short distance of that part of the cathodal lead from the coil or Wimshurst which lies close to the tube. A simple earthed wire may be used, but the foregoing plan is much better.

Not only is the discharge of X rays made much more regular by the ring and wire arrangement, when the adjustments are carefully made, but the X rays can be produced from a tube with a far weaker current; in fact, the weakest current capable of making sparks between the ring and conductor seems capable of giving the X rays, though they are more copiously emitted with a stronger current, and not only so, but the ring and wire seem to prevent the tubes from becoming fatigued. I have caused a brilliant emission of X rays from a tube which was previously "fatigued," at any rate, my coil was too weak to excite it, and the radiation was sustained for more than two hours, with but a few short intervals, without showing any signs of diminution,

judging by the effects on the fluorescent screen; but on withdrawing the ring and wire, it at once failed to give any.

Even breathing very gently, or blowing gently, for a moment on the tube, specially on the parts of the tube above mentioned, produces a marked bright flash, which examination will prove very rich in X rays, a fact first noticed by my assistant, Mr. P. H. Walter.

It follows from this that "fatigue" is not altogether due to the diminution of free particles in the tube by occlusion, which is commonly believed to be the case, but to a kind of polarization, in which the glass of the tube acts as the dielectric separating a −ve charge on the interior surface, from a +ve on the exterior; both the X rays and the fluorescence in the tube being in some way dependent on the electrical oscillations consequent on the intermittent discharge of this condenser. The tube also gives X rays plentifully when only the +ve terminal of the induction coil is connected in the usual way, and a wire from earth leads to what is usually the cathode, but only, so far as my experiments go, when the ring and wire are used, this last-mentioned wire in this case being also put to earth. The emission of X rays is not stopped if, under these conditions, the wire leading to the cathode is insulated. On the other hand, if the cathode lead only is retained and the anode lead insulated, or led to earth, the tube gives no sign of X rays. The +ve anode seems, therefore, in some respects to govern the emission of X rays.

In one experiment a ring was placed round the glass in the plane of the edge of the cathode mirror of a Crookes' tube intended to show the "independence" of the +ve pole, a tube from which no X rays could be obtained, and it was found that on extracting from the ring a series of small sparks by means of an earthed wire, there was a very decided increase in the brilliancy of the general fluorescence of the tube, but it gave no X rays; incidentally it was also noticed that when a wire brush, earthed, was pressed lightly over the dark spot opposite the cathode, which spot shows the hollowness of the cone of rays sent out by the cathode, in every place touched by the wire brush a most brilliant fluorescence was produced, which faded away very quickly when the brush was withdrawn. It is, therefore, certain that much may yet be done to increase the efficiency of X ray tubes without increasing the means of exciting them, by the study of the action of neighbouring conductors upon them, to say nothing of the light such experiments throw on the nature of operations within the tube by which the various fo of radiations which emanate from it are produ

(June 18, 1896.)

Although nearly two years have passed since experiments to be described were made and recorde *Nature*, the writer does not think it amiss to call sp attention to the next part of this paper on X ray with a Wimshurst machine, the first account of wo the kind published.

IV. The machine used in these experiments has already referred to, and it need only be added that h driving is sufficient to obtain the results describe most important point, since it renders unnecessary battery and coil, and brings the copious producti X rays of any kind within the reach of the many have neither, and to whom the expense of a coil c management of a battery are inconvenient, thou the writer's own case, to secure greater personal fre and uniformity of speed of rotation, he used a motor, driven by accumulators, and regulated by ance coils—a plan which proved very valuable wh was obliged to work without assistance.

Two small Leydens are attached to the Wimsh the ordinary way; two well-coiled and insulated lead from the brass knob terminals of the machine ends of the X ray tube. These two wires, whi supported on insulating posts, terminate in small knobs at each end, and are *not* in actual conta either the Wimshurst's terminals, or with th terminals of the tube. There are thus 4 spark-ga it is the magnitude of these gaps which is of s importance in all the experiments described. I sake of brevity they will be denoted thus:

N gap between −ve knob of Wimshurst and wire to cathode.

P gap between +ve knob of Wimshurst an wire to anode.

K gap between coiled wire to cathode and terminal itself.

A gap between coiled wire to anode and terminal itself.

Experiment 1.—Make N and P about ½ inc ceedingly small, and K about ½ inch. The res the machine is being turned as quickly as is co is a series of discharges, during each of which flashes out a brilliant, almost orange-green, colo on the fluorescent screen a light so bright

almost painful to the eyes. The shadow of the hand will show at once that the rays the tube is emitting pass almost as readily through bone as through flesh. These are the X3 rays (first noticed and recorded by Professor Silvanus Thompson in April, 1896) which seem likely, if the X radiation is undulatory, to have a shorter period than that of the X1 rays.

By means of this arrangement and a small X ray tube designed for a 4-inch spark, the ordinary shadow experiments may be shown to a large roomful at once. Three or four persons can see at the same time the backbone and ribs of a man, if a little care be taken to exclude extraneous light. The rays excite a fluorescent screen after penetrating a thickness of 8½ inches of solid brick, 1½ inches of plate-glass, 3 inches of water (easily), and 37 inches of wood.

Experiment 2.—Arrange so that the spark-gap A is exceedingly small, and N and P about equal, and as great as possible, provided that a discharge passes through the tube; then take a piece of thoroughly wet string, and fasten one end of it to the cathode terminal of the tube, the other to the end of the coiled cathode lead next the tube. A few strands of lamp-wick answer even better. Now move the cathode coiled lead away from the tube's neighbourhood, carrying, of course, one end of the string with it, until there is no direct sparking through the air, but all the discharge goes through the string. If the length of the wet string be right, the radiation will be found to consist of X2 rays; in fact, it is fairly easy to secure on the fluorescent screen a perfectly black shadow of the hand, the rest of the screen being at the same time brightly illuminated. By shortening the effective length of the string, the character of the shadow changes, the flesh becoming more and more transparent, whilst the shadows of the bones remain black for a while, until when the direct disruptive discharge through the air begins, when the X3 rays are immediately restored, and the radiation easily penetrates both flesh and bone. Thus, by loading the circuit more or less, the character of the radiation is altered. We already know that the discharge of a condenser, *e.g.*, a Leyden jar, is oscillatory, and that its frequency of vibration is very high. We also know that the frequency is lowered, and the oscillations damped by the use of a wet string, or other resistance, placed in the condenser's discharge circuit. Hence it appears reasonable to suppose that it is this slackening of the electrical oscillations which produces the corresponding change in the X rays emitted, and we see that this slackening can be produced by altering the resistance outside as well as inside the tube, perhaps, indeed, at any point of the circuit, so long as the discharge remains disruptive in character. In the experiment now considered, the discharge through the 3 spark-gaps, and therefore through the whole circuit, is certainly disruptive; but the influence of the wet string on the rest of the circuit, including, of course, these gaps, is strikingly shown by the altered appearance and sound of the sparks at N and P. The wet string, therefore, causes the tube to produce rays of the same kind as the heating of the tube, and if the effect of heat is to increase the general conductivity, it would seem to follow that the wet string must do the same thing. It is, moreover, obvious that the wet string takes the place of a rather wide air-gap, and it can very easily be shown by experiment that the air-gap possesses the greater resistance. Hence it might be thought that the vibrations in the case of air would be more slowly executed; but it must be remembered that in these experiments we have to do, not with the ordinary resistances of air and string, but with their resistances during the disruptive discharge, two very different things. The air, at ordinary pressures, can withstand a great electrical stress without giving way, but when once its initial and great resistance has been overcome, its resistance may be for the time very greatly diminished, so that the electricity surges backwards and forwards, it may well be, at the rate of many millions of times in a single second; whereas, in the case of the wet string, although it opposes at first far less resistance than air, yet its resistance never breaks down completely, perhaps for this very reason. The air and the string may be compared in this respect to an oak and a reed in a gale of wind: the reed, though it bends, still resists, is always resisting, and the more it is bent the more it resists, whilst the oak stands unmoved till it is broken or uprooted, and its resistance overcome.

That the oscillatory discharge is necessary for the production of the X rays, I feel little doubt; it would, however, be an extremely interesting experiment for anyone who has the means and leisure to try whether they can be produced by the so-called continuous current from a battery. A very few thousands of cells would seem likely to be necessary, and if anyone should construct a tube according to the hints and instructions given in the latter part of this paper, I think the number necessary may be a good deal smaller. The discharge of a

Wimshurst without Leydens, and with the 4 spark gaps nil, is still disruptive, though I expect less so when, unlike mine, the rotating plates are without sectors and buttons. A rotating mirror shows that even the silent brush discharge is disruptive—certainly the thin blue sparks are so, and the discharges from the rotating plates on to the combs, and between the two plates themselves, are all disruptive.

[NOTE ADDED JUNE 6, 1898.—I am informed that sectorless and buttonless Wimshursts do not give X rays, presumably, if this be true, because the discharge in this case is not sufficiently disruptive.]

Experiment 3.—The spark-gaps being arranged as for *Experiment* 2, instead of the wet string, the secondary of my 4½-inch coil was inserted in the circuit; the rays then given off by the tube were X1, which gave the most exquisitely bright and defined shadows on the screen, whilst, at the same time, the discharge through the coil gave rise to very decided Hertz effects for a long distance from it. It is clear that a rheostat of some rather high resistance wire, or other substance, would be most convenient to use with a tube, and that by means of it we could adjust the resistance of the circuit to give the exact kind of X radiation required for any particular purpose.

[NOTE ADDED JUNE 6, 1898.—Since the above was published, many attempts have been made to secure this power of making the tube emit any kind of X rays at will, but none of the ways which have hitherto been proposed seem to the writer nearly so simple or advantageous as the above plan of varying the resistance of the circuit by a suitable rheostat.]

The nature of the spark discharges at N and P during the emission of the X rays deserves close attention. At times the sparks resemble a string of equidistant silver beads on a bluish violet thread; and looking at them, one cannot help thinking these beads reveal stationary waves. To a trained ear, the changes in the pitch of the musical note emitted by these sparks, which accompany the changes in the character of the X radiation, are exceedingly suggestive. (November 12, 1896.)

V. On the patches of bright-green fluorescence which are wont to form in some X ray tubes, *specially* when excited by a Wimshurst machine, when spark-gaps are *not* used.

When an X ray tube is connected directly to the two knob terminals of a Wimshurst, the emission of X rays is often very satisfactory at first, in fact, some of the clearest, most sharply defined, and steadiest shadow the screen have been given in this way. But aft time the character of the discharge is apt to a beautiful patches and streaks of a very bright grass-g colour make their appearance on the inner surface o glass; and when one of these has formed, the X discharge becomes weaker, two or three of these pat proving altogether fatal to it, even if the machine excellent working order. When once a patch has for too, it seems to cling obstinately to the place wh develops. It was suggested to me that these pa were invariably associated with bubbles in the gl the tube, but on touching the tube lightly with a ca hair brush dipped in rather dry Indian ink, and painting over these green spots whilst they were vi and afterwards removing the ink spot by spot, examining for bubbles, I found that in many case were not present where the fluorescence had been and also that there were many bubbles whe fluorescent spot had been painted. These spots the shortest lines which can be drawn on the glas the cathode to the anode. They are far more nun near the cathode, forming near it, and often gra elongating towards the anode. Blowing gently middle part of the tube causes their retreat toward birthplace, and often extinguishes them alto Their forms are those which slightly divergent matter would take, if they were thrown ou different points on the sharp edges of the cathod impinged first on the inner surface of the bulb ve the cathode, exciting fluorescence so long as the composing the jets retained a velocity above a limiting value. If this be so, and the matter be charged, and if the glass surface acts towards rough surface does to a stone—perhaps on accou high electrical resistance—it becomes easy to s the patches are small and spread slowly when s E.M.F. is used (for the particles being similarly ele must repel each other), and also how it is t dissipation of the +ve charge which lies on the of the bulb leaves these jets of −vely electrified more free to take a shorter path to the anode. they hit the glass at all when the external c drained, they will do so further and further f cathode. This also explains why the fluorescent travel towards the anode region of the bulb v neighbourhood of the cathode is deprived of its +ve charge by gently breathing on the glass in

of the bulb. Similarly, it also explains why the patches travel cathode-wards, when the middle and anodal region is drained in any way of its external +ve charge, for then the attraction in the cathodal region is practically strengthened by the weakening of the attraction to the other parts of the glass of the tube. Not only do these jets impinge on the inner side of the glass, just by the cathode, under ordinary circumstances, when no pains are taken to drain the external +ve charge of the tube; but they are partly reflected after the first impact, when, owing to the attraction of the +ve external charge, the path of these reflected particles is bent towards the glass surface, and in many cases a fainter patch of a longer shape is formed, which lies further from the cathode by a second impact (and I have seen even a third patch formed in the same way after a second reflection), so that the inner surface of the tube tends to become covered with these fluorescent patches, smallest, brightest, nearest together, and least elliptical, near the cathode, and becoming progressively larger, fainter, further apart, and longer in proportion to their breadth, the nearer they approach the anode.

This has an important application, for, seeing that the formation of these patches is, by experiment, inimical to the creation of the X rays, anything which tends to the formation of these patches must be carefully avoided; and if, as I feel convinced, the jets are due to the sharp edges and small irregularities on the edge and concave surface of the circular mirror cathode, no pains should be spared to give that electrode a perfect polish on the side facing the anode, and to make its edge circular, and not square, as the circular cathode's edges are in my tubes. Another way of partly overcoming the formation of the jets is to make the tube wider round the cathode, or, what amounts to the same thing, to push the cathode well forward into the globular part of the tube. This last is already done in some forms of tube, I believe, with excellent results.

A striking experiment is to arrange a tube to give the green patches, and then to breathe rather strongly on the cathode half of the tube, two or three times if necessary, and watch how the fluorescent patches fly towards the anode as the external +ve charge is dissipated, and at last just meet behind the anode, making the whole of that region brightly fluorescent. Finally, if the external +ve charge is sufficiently dissipated, part creeping, part bounding along the glass tube which encloses the anode's wire, into the naked part of which wire, or the back of the anode itself, these cathodal jets finally yield their −ve charge.

I think that anyone who will take the trouble to repeat the very easy experiments here recorded will feel convinced that the foregoing is the true explanation of many of the widely observed, but perhaps hitherto unexplained, variations in the behaviour of X ray tubes. The last experiment suggests that it would be a good thing (*a*) to completely surround the anode stem, and perhaps the back of the anode itself, with some insulator, glass would probably prove best; and (*b*) if the anode be platinum, or, indeed, in any case, to make its edges very blunt and smooth. It may be well still further to encourage the discharge to take place solely in the straight line from cathode to anode, (*c*) to make a small area of the face of the anode facing the cathode large enough to include the point whence the X rays seem to emanate, rough or "matt," with, say, platinum black, in order that over this small area, to use old-fashioned language, the density of the +ve electrical charge may be as great as possible. It would also seem natural to suppose, so far as these considerations go, that it would be well (*d*) to push both the anode and cathode far into the tube, so that they are fairly close together, for this would certainly tend to prevent leakage to the glass of the bulb. I have heard that very excellent results have been already obtained with tubes in which the electrodes are but a very few millimetres apart; but there are other considerations which would show that the approximation of the electrodes may make an enormous increase in the E.M.F. necessary to obtain any radiations from such a tube. And, lastly, it may prove a decided advantage (*e*) to make the anode convex towards the cathode, and fairly small, though not *very* small. For each tube there will probably be a size which is the best, depending, among other things, on the size of the glass bulb.

Whatever the nature of the jets may be—and I suppose most will be inclined to believe that they are particles of the residual air, for there is very little evidence of any scattering of an aluminium cathode, save on the inner surface of the glass very near its edge—it is clear that the effect of the external +ve charge is to create a higher vacuum in the central portion of the tube by drawing the particles to the inner surface of the tube; and this explains the action of a flame on the tube, which is twofold—it not only drives off from the sides, and possibly from the electrodes, particles of moisture or occluded gases, held by some forces other than electrical,

but also speedily dissipates the external +ve charge, and thus sets free the "electrically bound" molecules, distributing the matter more evenly over the internal space, and thus makes the passage of the electricity between the electrodes easier. At the same time, the fluorescence which is produced by the impact of these particles against the glass becomes evenly distributed. (November 12, 1896.)

VI. The last part of this paper describes some experiments suggested by a paper sent to *Nature* by Messrs. A. Vosmaer and F. L. Ortt:

Messrs. A. Vosmaer and F. L. Ortt, in a paper kindly forwarded to me by the editor of *Nature*, have arrived at the conclusion that the X rays are more or less perfectly discharged particles of matter. Others—Sir William Crookes, for example—have suggested a material nature for the rays; and the only novel point in the paper referred to seems to me to be that the rays owe their greater or less *penetrative power* to the fact that they are particles less or more free from electric charges. Were this the case, it seems scarcely possible that the particles could pass as freely through, and in the neighbourhood of, a conductor when charged as when uncharged. If the particles were completely uncharged, it is true that they should be equally affected by a conductor first charged +vely, and then with an equal −ve charge. On the other hand, were the particles +vely charged, they would experience stronger attraction to a conductor −vely electrified than to the same conductor when carrying an equal +ve charge; and the same may be said, *mutatis mutandis*, if the particles be −vely charged. The effect one might reasonably expect is, that the uncharged particles would at first be attracted by a charged conductor, and then repelled from it if they acquired part of its charge, in which case the photographic image of the uncharged conductor produced by the X rays would be modified in intensity, if not in form, probably in both. The alteration in form, and to a certain extent in intensity also, will depend partly on the velocity with which the particles are travelling. I do not remember reading of any determinations of the velocity of propagation of the X rays; but if this remains very high over great distances, as it seems to do, it would appear extremely unlikely that the X rays consist of material particles, and if the velocity does *not* remain high, the radiographs are the more likely to show the variations suggested. If, as Messrs. Vosmaer and Ortt suppose, the rays are diselectrified by striking against the charged anode inside the tube, it is difficult to see why they should not be recharged, and thereupon like other charged particles, if they strike against an electrified conductor outside the tube, especially if the potential of the *external* conductor be as great or greater than the potential of the *internal*. Indeed, the authors of the paper admit this; and if it be correct reasoning one may reasonably expect to find some action such as I have sought for. Experiments were therefore made to see if the X ray photograph of a conductor, such as a small plate of aluminium, with carefully rounded and smooth edges, differs according to whether it be charged or not; and, secondly, if the photograph taken when it is charged +vely differs from that obtained when it is charged −vely. According to the paper alluded to the X ray particles are to be considered free from charge when they completely discharge a charged and insulated plate, without afterwards imparting to it a charge; but as will be remembered, *all* the X rays with which I have had to do have been of this description, including, of course, those given out by the tube used in the following experiments.

In the first set of experiments, two small squares A and B, with rounded edges, cut from the same sheet of aluminium, and $\frac{1}{30}$ inch in thickness, were arranged in the same horizontal plane beneath the Jena "focus" tube, and placed symmetrically with respect to the anode of the tube, so that the line joining the centres of the squares was in a direction at right angles to the line joining the centre of the anode and the centre of the cathode mirror. Below these small squares, and resting on a thick block of paraffin, was placed the photographic plate (all the plates used in each of the first two sets of experiments belonged to the same batch—the Ilford special rapid—and were developed together in the same large dish). The tube was worked by a large induction coil giving 6-inch sparks, and A and B were electrified when necessary, by wires from the poles of a Wimshurst machine (with Leydens), giving 7-inch sparks between the knobs when used in the ordinary way; this was, of course, verified before and after the experiments. The duration of each exposure was timed with a stop-watch in each case, and was, as nearly as possible, the same for each set of experiments.

A blank experiment made in each set, in which a plate, wrapped in dark paper (the same number of folds in every case, and of the same paper), was exposed to the radiation from A and B, *without* the Roentgen

proved that no photographic effect was produced by the inductive action of the Wimshurst.

Exposures were then made as follows :

1. A and B earthed by a wire soldered to a gas-pipe.
2. A +vely, B −vely electrified.
3. A −vely, B +vely.
4. A +vely, B to earth.
5. A −vely, B to earth.
6. A and B both earthed.

Development showed that the electrification of A and B was without effect, either absolute or comparative.

Since in the above experiments sparks passed between A and B when their potential difference exceeded an amount far *less* than that which could be given by the Wimshurst, and it seemed possible that a stronger charge might still yield some indication of the difference sought, one of the aluminium squares was removed, and the other shifted till it was immediately beneath the anode, and a second set of experiments was made in a rather different way. In each pair of exposures the same plate was used, each half of the plate being protected in turn, whilst the other half was exposed, by a thick slab of plate-glass—proved by experiment to allow no developable action of the X rays to pass through it during the time of exposure given. The experiments were as follows :

1. A blank experiment, *without the X rays*, in which one-half of the plate was exposed, first to A charged +vely to the full power of the Wimshurst, and then the other half to A charged −vely in the same way. The result showed there was no developable action.

2. First half, to X rays only ; then an interval of rest (the same interval being allowed between every experiment), then the second half to the X rays only ; this was done to see how the emission of the tube varied.

3. First half A +vely charged ; second half, X rays only, A to earth.

4. First half, A −vely ; second half, A to earth.

5. First half, A +vely ; second half, A −vely.

6. First half, A insulated ; second half, A to earth.

7. Same as 2.

8. Same as 1.

The whole of this series was then repeated, using the contents of one box of Edwards's Isochromatic plates. Development showed no action which could possibly be attributed to the electrification of A.

In the third set of experiments, A was connected by a wire, first to the cathode loop, and then to the anode loop of the focus-tube, and radiographs were taken, comparing the effects of this treatment with that of earthing A ; but these, too, gave no indication of any increase or decrease of the X rays reaching the plate, nor of any redistribution of the rays after passing near to, or through, the very strongly-charged external conductor.

In a fourth set, the photographic plate was placed on an ordinary discharging-table, and brush discharges, and afterwards thick sparks, were passed between the poles of the discharger (raised, of course, well above the table on which the sensitive plate lay), and the radiographs were then developed ; but they showed no traces of any action which could by any possibility be assigned to the sparks.

I therefore conclude that the radiograph of a conductor (though it is true I have only tried aluminium and brass) is not sensibly altered by even the powerful electrification of that conductor, nor are the X radiations altered either in intensity, kind, or direction, in passing through common air in the neighbourhood of a powerfully charged conductor, nor yet through air which is being subjected to a violent disruptive discharge.

This seems to me to make it decidedly harder to believe with the above-mentioned gentlemen, that the X rays are due to particles, whether such particles be supposed either totally or partly devoid of charges of positive or negative electricity. (July 5, 1897.)

CATHODE RAYS AND SOME ANALOGOUS RAYS.

By PROFESSOR SILVANUS P. THOMPSON, D.Sc., F.R.S.

(*Abstract of a Paper read before the Royal Society.*)

THE experiments first described were carried out to discover whether, and in what way, the shadow cast by the so-called cathode ray was affected by the physical state of the object interposed between the cathode and the tube wall, or other opposing surface capable of luminescing under the stimulation of the ray.

In the first series of experiments, a pear-shaped Crookes' tube was employed, having a flat disc at the smaller end, and two short cylindrical electrodes introduced transversely opposite the disc. Observations were made with these electrodes and disc connected up in different ways, especially as to the shadows of the

cylindrical electrodes, the conclusion drawn being that the size of the cathodic shadow of an object depends upon its own electric state. If it is positively electrified, the shadow contracts; if negatively, the shadow expands. To verify these results, other tubes were constructed with electrodes in different positions. With regard to the alterations which take place in the size of a shadow, it appeared that the enlargement of a shadow when the object is made cathodic, and the diminution of the shadow when the object is made anodic, both depend upon the degree of exhaustion of the tube, and both are augmented by raising the degree of exhaustion. It was also observed incidentally that two cathode beams are capable of passing through or penetrating one another just as two beams of light will.

The next series of experiments were made with electrodes covered with glass. In a bulb containing a narrow glass tube, into which mercury could be introduced, the usual shadow was cast on the opposite wall, and gave identical shadows when filled with mercury and when empty. At a certain degree of exhaustion changes in the shadow became obvious, and contracted slightly when the mercury was made anodic, but expanded enormously when the mercury was cathodic. The results appeared to show that the electrostatic deflection of cathode rays by an electrified object is dependent upon the surface of that object as to whether that surface is or is not conductive; and that for objects protected by a non-conductive layer, there is a certain minimum stage of exhaustion, below which they cause little or no electrostatic deflection of the rays.

Many Crookes' tubes show the phenomenon of "splashing," which is independent of the kind of glass used, the surface of the glass opposite the cathode appearing to be "splashed" by the cathodic discharge. It occurs at a particular stage of exhaustion, a little below that needed for the production of Roentgen rays. The dendritic forms assumed by the splash resemble the Lichtenberg's figures (of the positive kind).

The explanation appears to be: At this stage of exhaustion the first portion of a cathodic discharge electrifies the inner surface of the glass where it strikes, giving it a negative charge, or making it temporarily cathodic. The presence of this charge electrostatically affects the next advancing portion of the discharge, and causes it to strike the glass a little on one side, further distorting the ray, the splash creeping outwards, spreading and fading out almost as fast as it is formed.

A wire was fixed across the interior of a tube so t
cast a shadow, and then heated to redness by mea
a current from a battery; the shadow was observe
be rather wider at the end by which the current
than at the end by which it entered.

It was not found possible to concentrate the
either by means of concave reflectors (as use
Crookes in his researches), or by means of a glass t
or metal cylinder, through which the stream was p
Neither were they concentrated by passing thro
helix of wire traversed by a current.

Further experiments were made for the compari
cathode with Roentgen shadows. In an L-shaped
with an anode at the angle, a concave cathode
end of one arm, and a piece of aluminium near t
of the other arm, a shadow of the latter was cast
end of the tube. This shadow was not produced
rays from the cathode to the anode were diverted
magnet. It can be observed at low degrees of e
tion when no Roentgen rays are produced, and a
to the highest exhaustion. If the exhaustion i
ciently high, Roentgen rays will be emitted fr
same anode, and two shadows of the aluminiu
will appear at the end of the tube. It is clear tha
are, then, two kinds of rays being produced at the
which differ in their deflectibility by a magnet
electrostatic forces, and in their power of pene
glass. These internal rays are not ordinary
rays, as they do not possess the property of
Roentgen rays when they impinge upon solid m
upon liquids (as shown by Roiti). The ordinary
rays may be called "ortho-cathodic," while t
internal rays emitted from the anode above d
may be termed "para-cathodic." The yell
luminescence on the walls of the bulb appears t
to these para-cathodic rays, and not to the
rays. If a magnet pole is brought close to the
the delimiting edge of the patch of luminescence
glass, that edge is seen to be distorted, while th
simultaneous distortion of the corresponding d
edge of the Roentgen ray emission observ
fluorescent screen.

It appears, therefore, that from the anticathod
there are emitted simultaneously with the Roen
and with a similar abnormal lateral distributi
cathodic rays, which differ from the Roentge
respect of their power of penetration, as well
electrostatically and magnetically deflectible.

differ from the Roentgen rays in being emitted at a lower degree of exhaustion than is necessary for the production of the former, and from ordinary (ortho-) cathodic rays in not exciting Roentgen rays where they impinge on a solid surface.

Following up the experiments of Wiedemann and Ebert, and also those of Lenard, who succeeded in transmitting cathode rays through a window of aluminium leaf in the wall of a tube into the open air, a tube was constructed that would give ortho-cathodic or para-cathodic rays as required, and fitted with sliding holders containing pieces of aluminium of different thickness, so that the rays could be sent through the same and fall on different luminescible materials. The effects of a magnet on the rays were also observed, the conclusions arrived at being (1) that the various constituents of a heterogeneous cathode beam are emitted in various proportions at different degrees of exhaustion; (2) that in the cathode rays emitted at higher degrees of exhaustion there is a greater proportion of the less deflectible rays; (3) that the least deflectible rays are those which most readily penetrate through a perforated screen when that screen is itself made cathodic.

A tube was made containing a helix of iron wire, through which the stream from a flat cathode could be made to pass. When a current was passed round this helix, the shadow of a wire inside the tube was rotated about 20°. The effect of a magnet outside this tube was remarkable. When placed with its poles on either side between the cathode and the helix, the luminescence on the glass was driven into two portions, the stream from the cathode being deflected to the upper side, and that from the near end of the helix to the lower side of the tube. There appeared also in this tube a blue cone of rays, proceeding from the inside of the further end of the helix.

Another tube was made with a wire near one end, to cast a shadow on the glass as before, but a screen of iron wire gauze was mounted between it and the cathode. When this screen was anode, there was the usual shadow of the wire and green fluorescence in the whole tube; when the screen was cathodic, that part of the tube between the latter and the cathode was green beyond the screen, and there was the blue cone of rays producing orange-tinted fluorescence as in a previous case. The yellow-green fluorescence extended through the glass, while the orange fluorescence was confined to the inner surface. The spectroscope showed that both colours were due to the sodium in the glass. It is proposed to call these rays last described "dia-cathodic."

These observations may be summed up as follows:

(1) When cathode rays fall upon a perforated metallic screen, which is itself made cathodic or upon a tubular cathode, there emerge beyond the latter some rays, here termed dia-cathodic, which are incapable of exciting the ordinary cathodo-luminescence.

(2) These dia-cathodic rays are not themselves directly deflected by a magnet.

(3) They are capable of exciting a different kind of luminescence, the luminescent surface emitting light which, in the case of sodium glass, shows a gas spectrum.

(4) They can cast shadows of intervening objects.

STUDIES IN CATHODE AND ROENTGEN RADIATIONS.

(Abstract of a Lecture by Mr. Campbell Swinton.)

In a lecture delivered before the Royal Institution on February 4, Mr. A. A. C. Swinton showed several interesting experiments with cathode and Roentgen radiations.

When a tube was encircled by a coil of wire carrying a current, rotation of the rays was shown by the shadow of a small screen in the bulb cast on the interior surface of the glass. In a tube held above the pole of an electro-magnet so that the cathode rays were thrown downwards towards the latter, the rays were drawn to a point at the pole, and the heating or bombardment so concentrated that the glass was easily punctured; and if the magnet were moved about under the tube so as to alter the position of the point on which the rays were concentrated, a pattern could be engraved by the erosion of the glass.

In another experiment illustrating the effects of concave cathodes as devised by Sir William Crookes and Mr. Jackson, two concave cathodes were fixed opposite one another in a tube, and a block of quicklime was placed between them; an alternating current of 20,000 volts pressure when passed through the tube caused a brilliant light to be produced—the light is irregular, from the emission and reabsorption of gas from the lime producing changes in the vacuum. Small holes are produced in the block of lime by the rays.

With reference to the distribution of the charge inside

the tube, it seems to be negative behind the cathode, and positive in the remainder of the tube, with the exception of the cathode stream from the concave reflector to the anode, which is negative. The cathode stream of electrically charged atoms proceeds at a great velocity through the centre of the bulb, and the anode stream of atoms positively charged returns to the cathode (at a lower velocity) round the outside of the cathode stream.

The splitting up of a cathode stream by a magnetic field was next illustrated—described by Birkeland as the "magnetic spectrum." The image thrown on the surface of the bulb may be photographed on a piece of sensitive film, the presence of Roentgen rays being also shown by covering part of the film with black paper. In this "spectrum" image Mr. Swinton pointed out that the greatest photographic effect was produced by the least deflected part of the cathode spectrum, *i.e.*, by that which is presumably travelling at the greatest velocity, and that the quality of the Roentgen rays was thus largely dependent upon the velocity with which the negative atoms strike upon the anticathode. Some valuable information was next given with reference to the variation of the resistance of the tube for different relative positions of the cathode and anode. With the anode in the centre of the bulb, higher E.M.F. was required to produce a given effect than when it was drawn back away from the cathode, which remained stationary. When the anode was fixed in the centre of the bulb, and the cathode moved towards it, a lower E.M.F. was required when they were near together. In each case the E.M.F. rose or fell suddenly up to a certain point and then remained almost constant, its relative intensity being approximately given by the alternative spark-length between the terminal knobs of the coil.

The greater the resistance in the tube and the higher the E.M.F., the greater is the penetration of the rays produced. Further, if penetrative rays are wanted, the access of atoms to the cathode must be restricted. To accomplish this, either the cathode must be brought back into the annex, or a special arrangement be employed composed of a conical glass shield that can be brought up from behind the cathode. Mr. Swinton showed a tube of this pattern that gave the same results as those first described.

To obtain clearly defined images, a pinhole camera is useful, with a sheet of lead pierced by a small hole through which the rays pass, the size and shape of active area of the anticathode being examined by aid of the image on a fluorescent screen.

With regard to the photographic effect of the Roent rays on a sensitive plate, it was pointed out that t are weaker than is often supposed. By comparison v a standard candle, Mr. Swinton found that the powe a good tube was less than one-sixtieth that of standard candle.

The discourse was concluded by a notice of different theories suggested to explain the natur Roentgen rays, by Professor George Forbes, Sir Ge Stokes, Professor J. J. Thomson, and others:

"With regard to the true nature of the Roen rays, there have been many theories. One of the is the theory first suggested to the writer earl 1896 by Professor George Forbes, and recently pendently enunciated and elaborated by Sir G Stokes, which imagines them to be frequently but ir larly repeated, isolated, and independent disturb or pulses of the ether, each pulse being similar, per to a single wave of light, and consisting of a transverse wave or ripple, but the pulses followin another in no regular order, or at any regular freq as do the trains of vibration of ordinary light.

"Then, again, there is the question of the mech by means of which the Roentgen rays are pro They are generated by the impact of the cathod upon the anticathode, and it is now becoming mor more certain that the cathode rays consist of nega charged atoms travelling at enormous velocity. accept this view, there are obviously several meth which we may imagine the Roentgen rays being ger by the impact of the travelling atoms upon th cathode. Each cathode ray atom carries a n charge, while the anticathode is positively cha that when the two come into contact an electri charge will take place between them. As the static capacity of the atom must be exceedingl the periodicity of oscillation and the wave fr will be enormous; while at the same time the os will probably die out with sufficient rapidity to only one or two complete periods. At the same t greater the difference of potential between at anticathode at the moment of impact, the gre be the amplitude of oscillation, and the more and far-reaching the etheric disturbances. Or imagine a more purely mechanical origin for the

rays. It is believed that the velocity of the cathode rays is enormous, being, as recently measured by J. J. Thomson, over 10,000 kilometres per second. Assuming that at the velocity of the cathode ray atoms these do appreciably drag the ether with them, there may be some ether effect produced analogous to the atmospheric effect that is noted as the crack of a whip or a clap of the hands, as each atom hits the anticathode and rebounds.* Or, again, it is conceivable that the phenomenon is merely one of heating, and that the cathode ray atoms are by impact with the anticathode raised to such an enormous temperature, that they give off for a short space of time supra-ultra-violet light. Taking a velocity for the atoms of 10^9 centimetres per second, as found by J. J. Thomson to be the minimum velocity of the cathode rays, and calculating the temperature to which a nitrogen atom would be raised if, when travelling at this speed, it were instantly brought to rest and the whole of its energy converted into heat in the atom itself, we have, according to the formula

$$T = \frac{V^2}{2JS},$$

in which T = the rise in temperature in degrees centigrade;
V = the velocity in centimetres per second;
J = joules equivalent;
S = the specific heat of nitrogen.

Showing that the rise in temperature is no less than the stupendous figure of approximately 50,000,000,000°C. This is upon the probably erroneous assumption that the specific heat remains constant; but there is obviously an ample margin to admit of a temperature being actually obtained enormously transcending the electric arc or anything of which man has any knowledge. Perhaps it may be objected that it is only when we come to deal with aggregations of atoms that we can speak of heat, and that a hot atom is a physical absurdity. If, however, we look upon heat as a rhythmic dance of the atoms, perhaps we may also contemplate the possibility of a single atom executing a *pas seul*, and giving pulses to the ether at each of its movements. In any case this difficulty disappears if we imagine the cathode ray particles each to consist of an aggregation of atoms.

"The fact that substances of high atomic weight form the most efficient anticathodes lends force to the suggestion that the Roentgen rays are produced in some way by the sudden removal of velocity from the atoms that form the cathode rays, owing to the collision of these latter with the comparatively stationary atoms of which the anticathode is composed; while the effect observed with the pinhole photographs of the anticathode, in which, as has been seen, the cathode rays that strike the anticathode most normally are the most effective in producing Roentgen rays, is also in accordance with this view.

"More than two years have now elapsed since the date of Roentgen's discovery, and nearly twenty years since the commencement of the researches of Crookes. Here, as always, we find that 'Art is long, opportunity fleeting, experiment uncertain, judgment difficult.' Thus wrote the Greek Hippocrates some twenty-three centuries ago, and time has not impaired the truth of the ancient aphorism."

* Since the above was written the writer's attention has been drawn to Professor J. J. Thomson's paper, "A Theory of the Connection between Cathode and Roentgen Rays," in the *Philosophical Magazine* for February, in which it is suggested that Roentgen rays consist of very thin and intense electro-magnetic pulses produced in the ether by the sudden stoppage by the anticathode of the electrified particles of the cathode rays.

ON THE SOURCE OF THE ROENTGEN RAYS IN FOCUS TUBES.

By ALAN A. CAMPBELL SWINTON.

(Read before the Royal Society, June 16, 1898.)

[THE writer has already described ("Some New Studies in Cathode and Roentgen Radiations," a discourse given at the Royal Institution on February 4, 1898) how he has found it possible to study by means of pinhole photography the active area on the anticathode of a focus-tube from which the Roentgen rays proceed.]

By means of a special camera he has now been able to make further investigations. The camera is illustrated in Fig. 1, where A is the pinhole in a removable lead disc secured by a brass cap to the brass cone B, which is lined with thick lead so as to be opaque to the Roentgen rays. D is a framework into which slides either the fluorescent screen E, or a carrier containing a sensitive plate should photographs be required. F is an observation tube for use with the fluorescent screen. It is made of insulating material to avoid danger of shocks.

With this apparatus directed at the anticathode of a focus-tube, it is easy with the fluorescent screen in place to take accurate note of the image of the active anticathode area which appears on the screen, and to observe the variations in form, dimensions, and brilliancy that take place under varying conditions. Similarly by replacing the fluorescent screen by a photographic plate in

a black-paper envelope, the Roentgen ray image can be photographed. Exposures, varying from one to thirty minutes, according to conditions, are found sufficient to impress upon the plate any effect that can be seen directly with the screen. It has not, however, been found possible, even with very prolonged exposures, to photograph anything not directly visible with the screen,

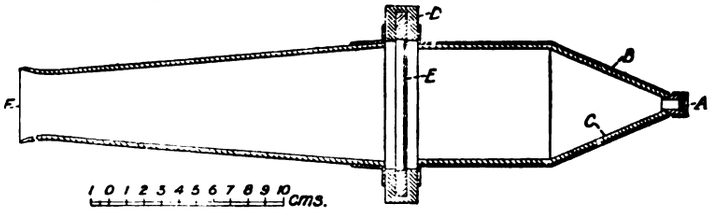


Fig. 1.

and having regard to the difficulties of maintaining the vacuum and other conditions constant for any considerable length of time, the method of direct observation seems generally to be best and most convenient. For direct observation, rather a large pinhole, say about 2 millimetres in diameter, gives the best results ; for photography about half this diameter is preferable, as it gives sharper images.

The writer has made numerous observations and photographs with this apparatus, both with focus-tubes of the ordinary pattern, and also with a special tube in which both the cathode and also the anticathode (which in addition acted as anode) were independently adjustable along the axis of the tube, so that the distance between them could be varied from a minimum of 4 to a maximum of 14 centimetres. This special tube is illustrated in Fig. 2, and during the observations it was connected to a mercury pump, so that the degree of exhaustion could be varied as desired.

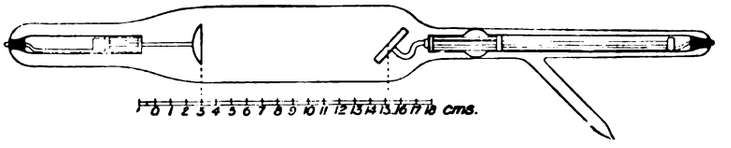


Fig. 2.

The following are the main effects observed :

(1) When the anticathode intersects the cathode stream at the focus, the dimensions of the active area are independent of the degree of exhaustion. For all other positions beyond the focus, it is larger the lower the exhaustion, and *vice versâ*. These observations are, of course, only possible between the limits of exhaustion with which Roentgen rays are produced.

(2) When the anticathode intersects the cath stream beyond the focus, the active area is larger greater the distance between cathode and anticath For instance, with the tube illustrated in Fig. 2 exhau to a good Roentgen ray vacuum, it was found that active area gradually increased from about 0·15 c metre diameter with 4 centimetres distance bet cathode and anticathode up to about 2·3 timetres diameter as the distance was grad increased to 14 centimetres. The increa less the higher the vacua, but is always considerable.

(3) When the anticathode intersects cathode stream considerably beyond the the active area is found to consist of a well-define very intense central nucleus, surrounded by a fainter but quite appreciable halo. Both of the crease in size as the distance between cathode and cathode is increased.

In some cases the halo consists of a well-m hollow ring with a dark space between it and the c nucleus. In other cases two distinct concentric are visible surrounding the nucleus. Moreove nucleus itself, when very large, shows distinct si being made up of one or more concentric rings, times with a still smaller nucleus within them. observations correspond with and amplify wh writer has already noticed by direct observation visible luminescence of a carbon screen arran intersect the cathode stream.*

(4) With an anticathode inclined at an angle of the axis of the conical cathode stream, it is four those portions of the stream which impinge most n upon the anticathode surface are considerably th efficient in producing Roentgen rays. larly those portions of the stream t pinge on the anticathode surface ver on the slant are correspondingly ineffe producing Roentgen rays.

(5) At the degrees of exhaustion most suita producing Roentgen rays, and with concave cath the usual dimensions, the cathode stream almost entirely from a small central portion cathode surface, the remaining portion of the being apparently practically inoperative. That so was very conclusively established by pho taken with the tube shown in Fig. 2. In th

* Royal Society Proceedings, vol. lxi., pp. 81-84.

facture or subsequent exhaustion of this tube three very minute fragments of glass by some means attached themselves on to the concave surface of the aluminium cathode, and remained fixed there during the experiments. The cathode itself was 29 millimetres diameter, and the radial distances of the three glass fragments from the centre were respectively about 9 millimetres, 4 millimetres, and 2·5 millimetres. In all the pinhole photographs of the anticathode of this tube in which the enlargement of the active area was sufficient, the shadows of the two glass fragments nearest to the centre of the cathode are clearly visible, while in none of them is there any appearance of the third and outer fragment. It, therefore, is evident that the whole of the cathode stream that was effective in producing Roentgen rays came from an area of the cathode surface less than 18 millimetres diameter, or less than two-thirds of the full diameter of the cathode. Further, in each case the shadows of the two inner glass fragments appeared outside of the central nucleus, showing that the whole of the more intense portion of the cathode stream proceeded from a portion of the cathode surface less than 5 millimetres in diameter. These results confirm the writer's observations made with carbon cathodes.*

(6) The different portions of the cathode stream proceeding from different portions of the cathode cross at the focus and diverge in a cone that retains any special characteristics of the convergent cone. The relative positions of the two inner glass fragments on the cathode, and the positions and enlargement of their shadows on the anticathode for different distances between the latter and the cathode, were found to show this very clearly.

(7) Though by far the greater portion of the Roentgen rays given by a focus-tube proceed from the active anticathode area, still, a very appreciable quantity is also given off by all those portions of the glass of the tube that show the green fluorescence.

Using a somewhat large pinhole, this is easily observed by turning the tube so that the more powerful rays from the anticathode cannot reach the pinhole, when a Roentgen ray image of the whole of the fluorescent portions of the glass of the tube can be distinctly seen. Further, it is noticeable that that portion of the glass that shows the brightest fluorescence, *i.e.*, that part which lies in the path in which cathode rays would be reflected from the anticathode surface were they reflected according to the law of equal angles of incidence and reflection, gives off the most Roentgen rays, while those portions of the glass that show no fluorescence do not give off any Roentgen rays. The conclusion appears obvious that whatever produces the one also produces the other, but as has been pointed out by Professor S. P. Thompson* and others, the fluorescence is not due to the direct stream of rays from the cathode, which cannot reach portions of the glass that show fluorescence, but to some description of radiation that proceeds from the surface of the anticathode that faces the cathode. In the paper above referred to Professor Thompson calls these radiations "para-cathodic rays," stating that they differ from the Roentgen rays in respect of their power of penetration, and in their capacity of being electrostatically and magnetically deflectable. In these respects the writer's experiments confirm those of Professor Thompson, but when the latter goes on to differentiate these rays from ordinary cathode rays, on account of their not exciting Roentgen rays where they impinge on a solid surface, the writer is unable to agree, for, as above stated, these rays do excite Roentgen rays where they impinge upon the glass walls of the tube; as mentioned, however, they do this only to an extent that is relatively very feeble, and, so far as the author knows, only discernible by the pinhole method of observation, which no doubt explains Professor Thompson's failure to observe the effect. The "para-cathodic" radiations in question do not, however, appear to be ordinary cathode rays. In the first place, they do not proceed directly from the cathode, but only from the surface of the anticathode that faces the latter. Secondly, they do not appear to be negatively but positively charged, as can be ascertained by means of an exploring pole connected with an electroscope. The writer suggests that, assuming the correctness of the Crookes' theory of the nature of the cathode rays, these "para-cathodic" rays may very probably consist of cathode ray particles which, having struck the anticathode, and having thus given up their negative charges and acquired positive charges, rebound, both by reason of their elasticity and also by repulsion from the anticathode. Perhaps owing to the comparative roughness of the anticathode surface, they fly off to some extent in all available directions, but they do so especially in that direction which the law of equal angles of incidence and reflection requires. It also appears very possible that these "para-cathodic" rays are identical with the positively electrified streams

* Royal Society Proceedings, vol. lxi., pp. 92, 93.

* See Phil. Trans., A., vol. cxc., pp. 471-490.

proceeding from the anode, which the writer has investigated by means of radiometer mill wheels, recently described in a paper to the Physical Society.

In any case, it seems clear that in the tubes observed and photographed with the pinhole camera, the Roentgen rays given off by certain portions of the fluorescent glass are not originated by the impact of an ordinary cathode stream, but apparently by the impact of positively charged streams proceeding from the anticathode.

The writer is greatly indebted to Mr. J. C. M. Stanton and Mr. H. Tyson Wolff, for the construction of the apparatus described, as also for valuable assistance in the carrying out of the experiments.

CURIOUS REVERSED ACTION IN A TUBE.

By ERNEST PAYNE.

WHILE experimenting with a tube a month or two ago, I noticed a curious effect, as if the action of the tube were in some way reversed, the current remaining in the same direction. I had connected a sheet of tinfoil (mounted on a glass plate) to the cathode terminal, to see whether it would have any effect on the action of the tube by retarding, as it were, the arrival of the charge on the cathode side, and having an effect analogous to a condenser. When first started, the light and shade in the tube were reversed, X rays were given off behind the cathode and from the back of the anode, causing the usual green fluorescence; the part usually illuminated remained dark, and no rays could be detected by the screen. The rays from the back of the anode were strong, and the bones of the hand were visible on the screen, while those from the back of the cathode were much feebler, although strong enough to show fluorescence two feet away and a shadow of the hand, but not to distinguish the bones.

The tube ran like this for about half a minute, and then suddenly reversed to its normal mode of action. I again tried it, without the sheet of tinfoil, and the same reversed effect was produced; but it only lasted a few seconds, and then ran in the usual way.

I could not account in any way for this action, as the tube had been working the day before in the usual manner. The anode of the tube was composed of a disc of aluminium, with a thin plate of platinum attached to it, and with the usual form of cathode. The effect seems to show the very unstable condition of things prevailing in a tube when in action.

SOME X RAY APPLIANCES.

FIG. 1 shows a convenient foot and leg rest for t radiographs of profiles. It consists of an upright A, fixed to a base B, with a movable block C, resti

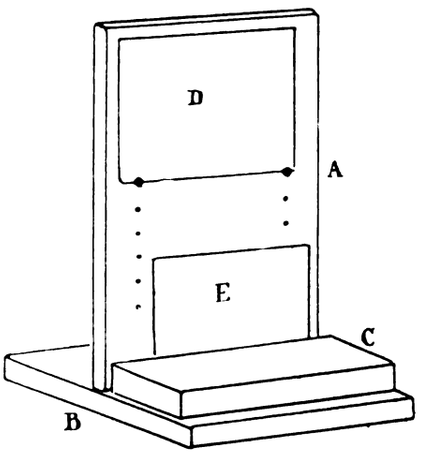


FIG. 1.

the base, and kept in position by dowels. This fixed a short distance away from the upright, allow the plate to pass down behind it. The fo

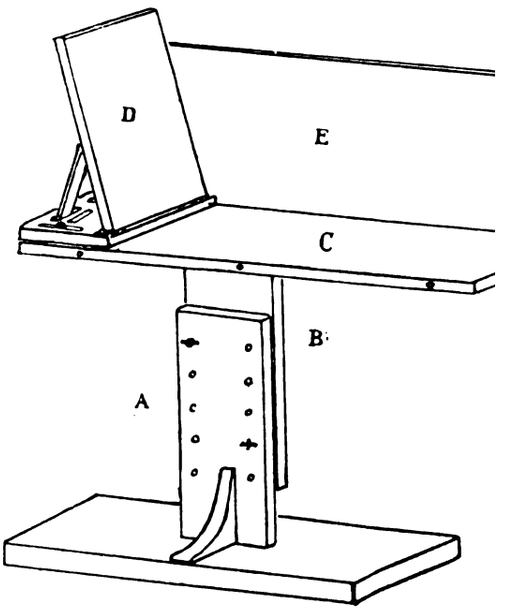


FIG. 2.

rests on C is thus slightly raised, so as to shadow more into the centre of the plate. F radiograph of a foot, the plate, enclosed in a

is placed as at E; in the case of a bent knee the plate is fixed on the upright board in the required position, as at D, resting on two large drawing-pins or suitable pegs fitting into holes made for the purpose. If the plate is on the tibia side, the upright, A, is held between the knees, and forms a most convenient and steady support.

Fig. 2 shows another form of rest, suitable for taking plans and profiles, which may be used when the leg is in a splint or cannot be bent. The upright support is made in two parts, A and B, one of which is fixed to the base, while the other is screwed to the board on which the leg rests; it can thus be raised to the height required. The sole of the foot rests against the support D, which is held in position by two screws, sliding in slots, and also fitted with a hinge, so that the angle can be altered. For taking plans, the plate is placed upon C or against D; for profiles an additional board, E, is fixed by removable screws to either side of C, as required, and the plate placed against it. The support D should be slightly narrower than the board C, so as to allow the plate to be passed along between it and the side board E, for taking profiles of the foot, thus bringing the image more into the centre of the plate. The drawings are from apparatus devised and used for the last two years by Mr. E. Payne.

Notes and Abstracts.

Analysis of Coal and the Testing of Gold Quartz.

M. Couriot has made a communication to the Académie des Sciences de Paris on the use of X rays for determining the purity of coal, lignite, anthracite, peat, etc. He finds carbon in all its forms to be transparent to the rays, while siliceous and other impurities are more opaque, the presence of the latter in a sample of coal being shown on the fluorescent screen.

The same method has also been applied to ascertain the presence of gold particles in quartz.

Adulteration and X Rays.

The presence of sand and chalk can be shown when put into flour to increase the bulk or weight, and many other forms of adulteration can be detected by the aid of X rays. Miss Fleischman has made some exhaustive experiments on this subject at her laboratory in San Francisco. Sugar adulterated with sand or chalk is more opaque than pure sugar. Chalk and alum can be detected if added to baking-powder. Tea and coffee were also examined, and impurities detected. Since vegetable substances are, as a rule, more transparent than minerals, and the latter are generally used for adulteration, their presence is the more readily detected.

Ophthalmology and X Rays.

Dr. Argyll Robertson, who presided over the section of ophthalmology at the recent British Medical Association meeting at Edinburgh, said that "no startling novelty or important advance had been made in this department of medical science during the year." But it may be pointed out that much useful and painstaking work bearing on the detection and localization of foreign bodies in the eye has been accomplished since last meeting. Apparatus for this purpose was shown by Dr. Mackenzie Davidson and Dr. Sweets, of Philadelphia. Many others have been working in this direction. M. Boucherin* recently showed a radiograph of shot in the orbit, after a perforating wound of the eye, and its exact localization, by X rays. Friedenberg† also calls attention to his method of determining foreign bodies in the eye. Will similar methods prove competent to reveal bony tumours of the orbit?

* See *Rev. Gén. d'Ophthalmol.*, No. III., March 31, 1898. † *Ibid.*

Portable X Ray Apparatus.

Portable sets of apparatus have already been designed and manufactured for field service, the question of the best form of battery being the chief difficulty. Some advocate primary batteries, made up at the time they are wanted; others have tried accumulators charged from a dynamo or a thermopile. In countries where labour is cheap the dynamo does not present so much difficulty as would be supposed, and if mounted, perhaps in such a way that it could be driven by the feet, like a bicycle, the operation might be rendered less arduous than driving by the hand. The small forms of oil-engines as used for motor-cars might also be tried. As to the methods of carrying the apparatus, Surgeon-Major Beevor, in his recent experiences in the Tirah campaign, found that the best mode of carriage was the transport of the country, viz., a bamboo pole carried between two bearers, with the box of apparatus slung on in the middle.

EXPERIMENTS ON THE APPLICATION OF THE ROENTGEN RAYS TO THE STUDY OF ANATOMY.

By ERNEST AMORY CODMAN, M.D., Boston.

THIS paper is the report by the author to the Committee on the Bullard Fellowship of the Harvard Medical School, May 1, 1897. After adverting to the fact that in pathological conditions of bone the X ray can reveal what the dissecting-knife and frozen sections cannot, the author proceeds:

In looking at skiagraphs, there are several distortions and inaccuracies which must be borne in mind. One essential for a good skiagraph is an accurately focussed tube. The cathode rays are focussed by a concave aluminium electrode on the

centre of a disc of platinum or the anode. The point where the stream of cathode rays strikes is the point from which the X rays are generated. That this point should be as small as possible is important, in order that no penumbra should be formed.

We may consider, then, that the X rays proceed from practically a single point. In looking at a skiagraph, we must consider it as a complete whole, made up of the shadows of the different parts of the object. The size and shape of the shadow of each part will depend on the relations of the distances between the point of light, the part of the object, and the plate. Thus the distance between the light and the plate remaining the same, the farther an object is from the plate, the larger will be its shadow; and the farther an object, or part of an object, from the base of the perpendicular from the point of light to the plane of the plate, the more will its shadow be distorted, the distortion being due to elongation in the direction of a line from the base of the perpendicular through the object.

When the object is at the same time away from the plate and away from the base of the perpendicular, both of these distortions will take place. Further, since each object or part of an object contains only a certain amount of shadow-casting material, the farther it is from the plate, the greater will be the size and the less the density of the shadow.

An important corollary follows from this. A picture of a less dense object may be taken through a more dense, *e.g.*, the ear through the skull. This can be done when the densities of the two objects are not greatly contrasted; but when one object is so dense as to be practically impenetrable to the rays, its shadow will of course obliterate the shadows of anything either in front of or behind it. This is generally true of metallic objects.

Another source of inaccuracy of these pictures is the fact that the rays, in penetrating large objects, are more or less diffused. This diffusion tends to blur the outlines of the parts of the object at a distance from the plate. It may also assist in making more distinct the objects in direct contact with the plate; for instance, in the picture of the ear taken through the skull, the diffused rays from the other parts of the head may help to take the picture of the ear, because they blur all those parts of the plate which are not protected by the ear, which comes in close contact with the wrapper.

It will be seen from the foregoing that in order to reduce these inaccuracies to a minimum the distance from the plate to the tube should be as great as possible, and that from the object to the plate as short as possible. The distance, therefore, must be gauged by the intensity of the rays and convenient time of exposure. We must also remember that the wider the object, or the deeper the object, the greater must be the distance between the plate and the tube. For instance, the skiagraph of a hand at 10 inches is very little distorted, while that of two hands side by side would be considerably distorted, because the rays would strike the outer fingers at more acute angles.

A knee at 10 inches, though little wider than a hand, would yet be considerably distorted, for it is so thick that the parts furthest from the plate would be much enlarged; the external condyle of the femur (the knee being on the inner side, for instance) would appear much larger than the internal.

In order to reduce these distortions to a minimum, the should be put as far away as is possible with a convenient of exposure.

On the other hand, however, advantage can be taken o distortion in taking a photograph of the patella. If the p put to the posterior side of the knee, the shadow of the p will be hardly, if at all, distinguishable. This would b also if the plate were on the anterior side and the lig away, for the shadow of the femur would be dense enou overshadow that of the patella. If, however, the plate the anterior side, and the tube very near the posteric shadow of the femur will be broadened and diminish density, so that the shadow of the patella, which is but magnified and as dense as before, will be seen through it.

The use of the fluoroscope is a practical way of deter the intensity of the rays. In determining the distance, w remember that the intensity of the light varies inversely square of the distance. In determining the time, we can late that what we lose by doubling the distance we g multiplying the time of exposure by four.

THE STUDY OF THE MECHANISM OF THE JOINTS.

This has been undertaken in two ways. First, by ski ing the normal joints in their forced extreme positions, e flexion, adduction, etc. Secondly, by watching the mov with the fluoroscope. As the parts of the object near th show best, it has been necessary to take each position fro sides.

One thing which will at once arrest attention is th distance that apparently intervenes between the bones. in part due to the fact that the articular cartilages, beir traversed by the rays, do not cast a shadow.

The wrist-joint has proved most interesting in thi and the points brought out will be found in the f description:

For convenience, we may consider the wrist-joint to up of four immobile and two mobile elements.

I. Immobile (*i.e.*, those made up of single bones or of of bones, the components of which cannot change positions). These are:

1. Metacarpal of thumb.
2. Metacarpal of ring-finger.
3. Metacarpal of little finger.
4. Metacarpal of index and middle finger with tr trapezoid, os magnum, and unciform.

This last group are so firmly attached to one ano they move as a whole, practically as one bone. N however, their ligamentous attachments allow of mor spring in strained positions of the hand brought external force.

II. Mobile (the components of which change relative

1. The intermediate row of carpal bones composed of semilunar, cuneiform, and pisiform.
2. Radius and ulna.

From skiagraphs it is found that the carpus and n are, in any of the extreme positions, in practically relation to the radius, no matter what the relati radius to the ulna, whether pronation or supination

due to the more or less flexible fibro-cartilage, which in any position completes the cup of the radial joint. The question of mechanism, then, is further simplified by leaving out the ulna, which really does not enter into the construction of the joint except as a pivot. The pisiform also does not enter the mechanism, serving only as a sesamoid for the ulnar tendons.

Proceeding to eliminate other accessory elements, we can disregard the metacarpals of the thumb, ring and index fingers, each of which moves independently on the large fixed element composed of the os magnum, etc. The thumb forms a typical saddle joint with the trapezium, with the pommels of the saddle so low that motion is allowed in a small circle, either as rotation within the circumference or straight motions on any of the radii. The metacarpal of the ring-finger is allowed a slight antero-posterior motion of a few degrees. That of the little finger the same of slightly greater extent, with possibly a degree of adduction. This leaves us with :

I. The large compound fixed element of os magnum, etc.

II. The radius with fibro-cartilage.

III. The intermediate element of scaphoid, semilunar, and cuneiform.

These constitute the real wrist-joint.

WORK ON THE X RAYS.

By T. C. PORTER (Eton College).

The first part of the paper deals with the different character of the radiations with respect to their power of penetrating flesh and bone (noted and recorded by Silvanus Thompson in the *Comptes Rendus* a month earlier), and describes the first *proof* that the differences visible on the screen are not merely due to variations in the intensity of the radiation or contrast, but are caused by a real difference in the X rays themselves. X1 and X2 suggested as a suitable tentative nomenclature for these different X radiations. The X2 rays obtained by heating the tube (June 4, 1896).

Effect of cooling the tube with solid carbon dioxide: the emission of X rays returns on the gradual warming of the tube very suddenly. Verification of work done by other experimentalists: (*a*) the X rays discharge *completely* an electrified and insulated plate, whether it be electrified +vely or −vely. (*b*) Are without effect on the blackened or bare face of an Sb-Bi thermopile, nor can any effect be seen when the face of the thermopile is covered with BaPtCl6. (*c*) On a radiometer the X rays alone have no effect whatever, and the reported effects are due to the strong +ve static charge which resides *everywhere* on the external face of the tube. There is a state in which the tube is filled with a whitish lavender glow, obtained by heating the tube and allowing it to cool, though it rather rapidly drains an insulated plate of either a +ve or −ve charge, when *unscreened* from the effects of static induction, yet it does not charge the plate either +vely or −vely. This is worthy of note, since, under ordinary circumstances, a tube which is emitting X rays acts on an *unscreened* and insulated plate, so as to leave it with a charge of a fixed magnitude, and always *positive*. The emission of X rays is simultaneous with the withdrawal of the lavender glow from the anode, and at the same time the potential of the space around the tube rises very rapidly.

The next part of the paper deals with the effect of neighbouring conductors, in particular of one in the region about the cathode; effect of a conducting ring outside the tube in the plane of the edge of the cathode; effect of bringing very near this an earthed wire; effects of the ring and wire in increasing the emission of X rays greatly, of preventing the tube from becoming "fatigued"; necessity for an intermittent discharge; view of the tube as a *condenser;* increased fluorescence of a Crookes' tube when a conducting sheet is applied to the external surface of the glass under a fluorescent patch (June 18, 1896).

The third part of the paper deals with the use of the Wimshurst influence machine for generating the rays in a tube. Extraordinarily powerful rays elicited in this way, penetrating 8½ inches of brick, 1½ inches of glass, 3 inches of water, and 37½ of wood. The X3 rays (first described by Silvanus Thompson in April, 1896). Arrangements of spark-gaps for maximum emission of rays. Effect of "damping" the oscillatory discharge on the kind of rays emitted by (*a*) wet string, and (*b*) the secondary of a coil used as a rheostat. Gradual passage from X2 through X1 to X3 rays by this means; bearing of this on the nature of the rays; peculiar beaded appearance of the sparks at the spark-gaps.

Study of the fluorescent patches sometimes visible on the glass of the tube. Their motions and change of form when the exterior of the tube is drained of its charge prove that they are due to stray jets from the cathode. Bearing of this on the best form for the tube, the cathode, and anode. Explanation of the rise of the degree of vacuum in a tube is to be found *chiefly* in the gradual "binding" of the particles of residual gas to, and in, the interior surface of the tube, by the static charge developed by them on the exterior surface, so that fewer and fewer particles remain free to carry the current between the electrodes (November 12, 1896).

Lastly, an account of a series of experiments made to ascertain whether powerfully charged external conductors change to an appreciable extent the direction the X rays take on leaving the tube: result, no action of the kind could be found; inference, it is difficult to believe, with Messrs. A. Vosmaer and F. L. Ortt (*Nature*, August 5, 1897), that the X rays consist of particles conveying static charges of electricity(August 7, 1897).

Rheumatoid Arthritis and X Rays.

We have received from Mr. Ernest Payne a negative of a knee from a patient suffering from rheumatoid arthritis. On the plate the tibia and fibula appear lighter than the surrounding tissues, showing that they are more opaque than the flesh, etc., but the shadow of the femur is distinctly darker than the surrounding flesh, etc., as if the opaque substances of the bone were not present. This transparency is also spreading to the patella, and to the head of the tibia. The outline of the femur is quite clearly defined. It is difficult to see how such an effect could be produced by any defect in the tube or plate.

It is to be regretted that the prints are too weak for reproduction, but this note is inserted with a view of ascertaining whether others have obtained similar results. The negative will be shown at the next meeting of the Roentgen Society.

THE ROENTGEN RAYS IN THE DIAGNOSIS OF PULMONARY TUBERCULOSIS.

At the congress on tuberculosis recently held at Paris, Bouchard and Claude (Paris) presented a long report on the application of the Roentgen rays to the diagnosis of pulmonary tuberculosis. In that disease at the outset the lesions consist of new formations (tubercles, isolated or agminated) constituting an obstacle to the penetration of air, and of congestion of greater or less intensity. At this time the fluorescent screen will show at one apex or both, sometimes at several places in the lungs, small spots, ill-defined at their circumference, or a slight mistiness veiling one apex; in other cases a kind of stippling of small shadows on a less dark ground. Confluent pulmonary infiltrations with a tendency to softening and ulceration give rise to almost complete opacities; these are darker in the case of lobar infiltrations, lighter in the case of lobular infiltrations. The intensity of the shadows is proportional to the defect in the penetration of air into the lung; if the lesion forms a compact, voluminous mass absolutely impenetrable by the air, the darkness shown on the screen is complete; if there is a number of little nodules separated by parts still permeable by the air, the general opacity is less intense, and on the dark ground are to be seen deeper shadows corresponding to points completely caseated. The formation of cavities reveals itself on radioscopic examination as on the plate, sometimes by an absolute opacity, sometimes by zones of relative transparency surrounded by spots of variable opacity. Absolute opacity is met with only in the case of cavities full of pus, or when the cavity is deeply seated and surrounded by pulmonary tissue stuffed with tubercles, or when a covering of dense adhesions prevents the passage of the light rays. If, on the other hand, the cavity is superficial, empty, and has a thin wall, it shows as a clear zone when compared with the neighbouring parts of the lung more deeply shaded; it is oval in shape, and sometimes the ribs in front of it are visible. When the cavity fills up, the clearness which marks its situation diminishes, and there is only a large shadow, rather less deep at one part than in the rest of its extent. Every degree of variation is possible, but the essential character in all forms of the radioscopic image of cavities is the presence of a very dark zone more or less annular in outline, encircling a region relatively clear or altogether transparent, whilst the rest of the lung in the neighbourhood is in shadow. It is the sharp contrast between these two elements of the lesion—spots re tively clear showing on a ground frankly dark, a shad fining off at the circumference and sharply cut round central clear zone—that is characteristic of a cav The pneumonic confluent form of acute phthisis reve itself on the fluorescent screen by complete opacity the diseased parts; this is explained by the fact that these points the lung is no longer permeable to Effusion at the base is shown by a thick shadow wh hides the diaphragm, and below is lost in the obscu of the abdominal mass, and above is limited by a zon penumbra directed obliquely from above down, from axillary region to the vertebral column, or in the sh of a curve concave at the upper border. Examinati at intervals of a few days will show the variations in extent in the liquid effusion by variations in the ex and form of the shadow. An intense opacity of gener rounded outline occupying the middle part of a lun which the upper and lower parts have almost reta their normal clearness suggests an interlobar effus Here, again, the variability of the shadows at diffe times is a help to diagnosis. Dense and exter adhesions of the pleura, on the other hand, man themselves by shadows less dark but constant in t form. In such a case it is often impossible to disting the condition of parenchymatous lesions by radiosc examination alone. Pneumothorax is characterize an abnormal transparency of one side of the chest, w allows the light to pass through without any interfer except over a small area on the affected side corresp ing to the retracted lung. The heart and the ve may be displaced; the curve of the diaphragm is l than in health. In hydro-pneumothorax and pyo-p mothorax the appearances vary according to the pos of the patient; if he is lying down, the whole o affected side is dark; if he is standing up, the upper of the part is more transparent than in the normal s and the lower is opaque. Even slight tuberculous ch in the pleura affect the mobility of the diaphragm general terms it may be said that in pulmonary t culosis there is a diminution in the movements of a and descent in the diaphragm; this change ma observed on one or on both sides. Radioscopi amination can also give important information as t condition of the mediastinal glands in tuberc patients. In acute or subacute bronchitis the two of the chest show little or no departure from the n state, and there is no change in the respiratory

ments of the diaphragm—negative signs which may be of some importance. In pneumonia there is complete opacity at the part corresponding to the lesion. This opacity, however, varies in its limits and intensity from day to day. The movements of the diaphragm are diminished on the affected side. Non-tuberculous broncho-pneumonic foci cause a slight opacity, but according to Maragliano this becomes less marked on deep inspiration. On the other hand, foci of pulmonary sclerosis, like patches of tuberculous infiltration, do not become clearer on deep inspiration. In simple emphysema the permeability of the lung to air is increased, and thus the transparency is exaggerated, and the ribs are less distinct. Moreover, the emphysematous lung is larger than natural, and extends into the pleural cul-de-sacs, so that the transparent surface corresponding to the organ extends more upwards towards the mediastinum, and particularly more downwards towards the abdomen. When the subject is examined at the back there is seen below the diaphragm a transparent surface of much greater extent than in the normal state. The authors conclude that the use of the X rays makes it possible in certain cases to discover commencing changes in the lungs at a period when other methods of clinical investigation give no indication. In other cases it defines the extent or reveals the importance of a lesion insufficiently disclosed by auscultation or percussion. Again, it enables the practitioner to reject the hypothesis of tuberculosis in cases where symptoms and clinical signs of doubtful import puzzle the clinician; while at the same time it often enables him to trace to their true cause general disturbances which clinical observation has failed to detect. Radioscopy is not merely a method of control, correcting or supplementing the ordinary methods, but it yields new indications. By making visible the working of the respiratory apparatus, it shows the functional value of one lung. It discloses the pleural adhesions, the pareses or ankyloses of the diaphragm, which limit the movements of expansion. In a word, it makes the evolution of the disease visible to the eye.

A. Beclère (Paris), in a communication on the same subject, said that for the exact and complete determination of tuberculous lesions radioscopy and radiography should be employed simultaneously. He dealt successively with the results obtained by the X rays in (1) latent, (2) suspected, and (3) declared tuberculosis. In latent tuberculosis the patient has every appearance of perfect health, and presents absolutely no physical sign or symptom of disease. The frequency of this state of things is shown by the large number of cases among soldiers who have died of various diseases in whom old unsuspected tuberculous foci have been found. Kelsch made radioscopic examinations on 124 men admitted to hospital in October and November, 1897, for various medical and surgical affections, all cases in which pulmonary tuberculosis could be recognised by the ordinary diagnostic methods being carefully excluded. The results were absolutely negative in seventy-three of the cases, but in the remaining fifty-one the fluorescent screen revealed abnormalities of various kinds—lessened transparency of the apices, enlargement of the bronchial glands, more or less marked opacity of the pleura, diminished movement of the diaphragm. These appearances were considered by Kelsch to be characteristic of tuberculosis. He adds that the screen, by allowing, as it were, a pathological examination of the lung to be made during life, confirms the conclusion to which he has been led by post-mortem examinations, namely, that in young persons latent tuberculosis exists in at least two or three of every five cases. The use of the X rays also serves for the identification of tuberculous lesions which disguise themselves under the mask of anæmia, chlorosis, dyspepsia, and neurasthenia. In cases of suspected tuberculosis, if the disease attacks the lung suddenly, radioscopic examination shows chiefly a diminution in the clearness of the image at the apex and in the pushing down of the diaphragm on the affected side. Tuberculosis may begin by an attack of diaphragmatic pleurisy, the symptoms of which are so slight that the only proof that the pleura is involved and that the case is not merely one of intercostal neuralgia is supplied by the Roentgen rays, which show thickening, diffusion, and immobility of the diaphragmatic shadow. If the case is one of dry pleurisy with "stitch" in the side, but without any decisive physical sign, radioscopic examination shows superficial opacities quite close to the thoracic wall. In cases of effusion the condition of the apex in regard to transparency on the affected side must be carefully investigated. Even a slight degree of opacity in the region of the apex is important in regard to prognosis. In declared tuberculosis the lesions are plainly shadowed on the screen. In such cases radioscopy is more valuable for prognosis than for diagnosis; it will show when both apices are attacked where clinical examination appears to warrant the conclusion that one is still intact, or when the lesions

extend lower down than is disclosed by ordinary methods. The X rays are particularly useful for the detection of central lesions, which on account of the depth at which they are situated are apt to be overlooked.—*British Medical Journal.*

THERAPEUTIC ACTION OF X RAYS ON TUBERCULOSIS.

On the same occasion J. Bergonié (Bordeaux) and Teissier (Paris) presented a report embodying the results of some experiments of their own as to the effect of the X rays on the tubercle bacilli, and reviewing critically the results recorded by Lortet and Genuod, Fiorentini and Lureschi, Müksam, Rodet and Bertin-Sans, and others. They conclude that animals infected with tuberculosis in various ways, and subjected for more or less prolonged periods of time to the action of the rays, die for the most part without appreciable modification of the lesions and without any retardation in the evolution of the disease. The results of clinical experiments were as follows :

1. *Cutaneous Tuberculosis.* — In lupus the X rays produce, as the light rays do in radiography, a dermatitis of greater or less intensity, and it is to this reactive inflammation that the effects are due. The difficulty is not to produce dermatitis followed by improvement, or even by temporary cure, but to limit the inflammation in respect of intensity and of duration. One has to bear in mind the long incubation period of these forms of dermatitis, and not to be misled by the absence of immediate reaction into making too long and too numerous applications. When the dermatitis can be graduated, the effect of the X rays in cutaneous tuberculosis is favourable.

2. *Tuberculosis of Joints.*—In the cases of tuberculous arthritis in which good results have been recorded it is impossible to separate the effect of the X rays from that of conservative treatment, particularly immobilization. The only thing definitely assignable to the rays is a local inflammation, which is of doubtful therapeutic value, and could be obtained by more manageable methods.

3. *Pulmonary Tuberculosis.* — If in some favourable cases abatement of fever, improvement of the general state, and sometimes, though more rarely, modification of the local condition, have been observed to follow the use of the rays, these good effects have not been lasting; the disease has followed its course, and the fatal termination has not been retarded by the treatment. In some cases acute pneumonic processes have been set up, which, if not certainly traceable to the rays, were in close relation of time to the application. Serious digestive disturbance has also been observed after the treatment. The authors sum up their conclusions in the statement that the results of the X rays on tuberculous pulmonary lesions have so far been almost entirely negative. Not only has the disease not been cured, but its evolution has not been stopped, or even checked. It may be taken as proved that up to the present time the action of the rays is, if not dangerous, of no therapeutic efficacy whatever.—*British Medical Journal.*

INFLUENCE OF THE X RAYS ON EXPERIMENTAL TUBERCULOSIS.

Rodet and Bertin-Sans reported that they had subjected guinea-pigs which had been inoculated in the thigh with tuberculosis to the action of the X rays. They varied the conditions as regards intensity, duration, and frequency of sittings and arrangement of the tubes. In some cases the treatment was begun a certain time after the inoculation (curative treatment), in some almost immediately (preventive treatment). The rays caused local trophic disturbances often of a serious character, in the form of extensive ulcerations in the regions directly exposed to the rays; the ulcerative process was favoured by pre-existing local tuberculous lesions. The rays had a bad effect on general nutrition, the animals treated showing less growth or greater loss of weight than the "controls." Death was generally hastened by the treatment. This was more particularly the case in the animals in which the rays produced caustic effects, but it occurred independently of this. The treatment had a manifest influence on the infection of the lymphatic system, determining a regressive action in glands already involved, and restraining general infection of the system. On the other hand, so far from restraining the invasion of viscera, the treatment to some extent favoured it. The spleen, the liver, the lungs were found, on the whole, more tuberculous in the animals treated than in the "controls." In no case did the rays have any beneficial result.—*British Medical Journal.*

Description of Plates.

PLATE XLVI.

A CASE OF GENU VALGUM.

By S. C. MOORE, Esq., M.B., Liverpool.

The case is that of a boy ten years old, under the care of G. G. Hamilton, Esq., F.R.C.S., at the Liverpool Royal Infirmary, brought with bad "genu valgum."

The skiagram, taken by Mr. Marsden, shows the bending of the tibiæ, also the thickening of the ends of the bones.

PLATE XLVII.

FRACTURE OF HUMERUS.

By Dr. CARL BECK, New York.

Represents a fracture of the surgical neck of the humerus, sustained by a boy of eight years of age two weeks before the skiagram was taken, which shows the fragments in excellent apposition, and also indicates the normal callus-formation. Time of exposure, four minutes; 14-inch spark; Edison blowing apparatus.

PLATE XLVIII. (*a*).

CASE OF TUBE IN ANTRUM OF HIGHMORE.

By Dr. F. H. LOW, London.

Mrs. H., aged twenty-four, under care of Mr. A. Cheatle, at Royal Ear Hospital, Soho, had tube put in antrum to drain the cavity. One morning, on awaking, missed the tube, and it was thought to have been swallowed.

Seven minutes' exposure; Cadett lightning plate; intensifying screen on plate. Tube—Watson—in use since end of 1896.

PLATE XLIX.

THREE FEMUR FRACTURES.

By ERNEST PAYNE, Brighton.

The three radiographs reproduced on Plate XLIX. show different forms of femur fractures resulting from different accidents. All three are cases of children, taken at the Royal Alexandra Hospital, Brighton. In each case two or more radiographs were taken before and after setting, that picture being reproduced which shows most clearly the nature of the fracture.

(*a*) The fracture was caused by the shaft of a waggon, which fell on the leg. A much better position of the parts was eventually secured.

(*b*) The fracture was caused by the wheel of a cab passing over the child's leg. A former radiograph revealed considerable displacement, which was reduced in setting, and coaptation is now very perfect.

(*c*) The child fell over the end of its bed on to the floor. The line of fracture is noticeable, especially at the upper part, presenting the appearance of a broken tube made of some brittle material.

PLATE L. (*a*).

By HENRY A. ROOME, M.B., Southsea.

C. M., aged sixteen, male. This case was sent to me by Dr. Wallace, of Southsea. The patient has a large protuberance on left side of neck, which prevents him turning his head to that side. The nature of this had puzzled many surgeons, but on the screen it was at once evident that it was formed by the three upper ribs, and enclosed a portion of the left lung. It has existed since the boy was six months old. He has a right lateral curvature of the dorsal spine.

In the radiograph, the ribs are seen high above the left clavicle, which is thickened at its sternal end. It was taken while the patient lay on his back. Nine-inch spark ; 6 volts ; iridium tube ; six minutes' exposure ; distance, 18 inches.

PLATE L. (*b*).

BULLET-WOUND OF THE RIGHT FOOT.

By WILLIAM MARTIN, M.A., M.D., M.S. (Durham), Newcastle-on-Tyne.

This case was sent to me by Mr. Rutherford Morison. The bullet was impacted in the head of the third right metatarsal bone. Brady and Martin's vacuum tube was used with a 10-inch coil, the tube being 9 inches from the plate, and the exposure one and a half minutes. It will be noticed that the outline of the sock is clearly defined in the skiagram ; the sock was an ordinary worsted one, and the meshes were filled with dirt and grease from the foot.

PLATE L. (*c*).

HALFPENNY—IMPACTED IN THE THROAT AT THE JUNCTION OF THE PHARYNX AND ŒSOPHAGUS.

By WILLIAM MARTIN, M.A., M.D., Newcastle-on-Tyne.

The patient, who was about three and a half years of age, was sent to me by Professor Oliver, with a history of having swallowed a halfpenny twenty-five days before. The tube and coil used were the same as in Case I., and an exposure of seven minutes was given with the tube 12 inches from the plate. The patient was lying prone, with the face turned to the right hand and the left arm extended at the back of the head. Incidental points of interest in the skiagram are the dental sacs, with their embryonic teeth, the upper epiphysis of the humerus, and the clearly-defined heart shadow.

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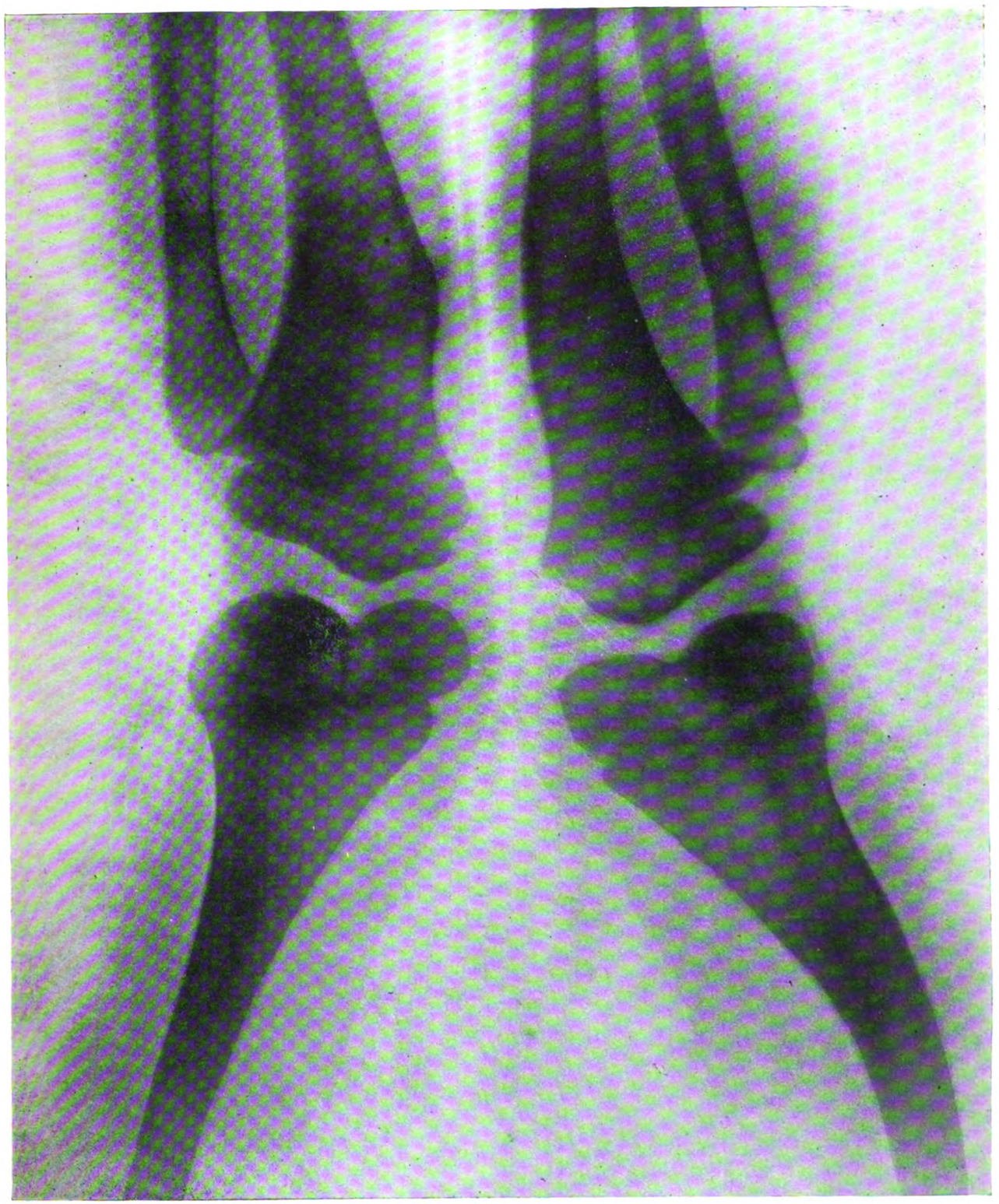
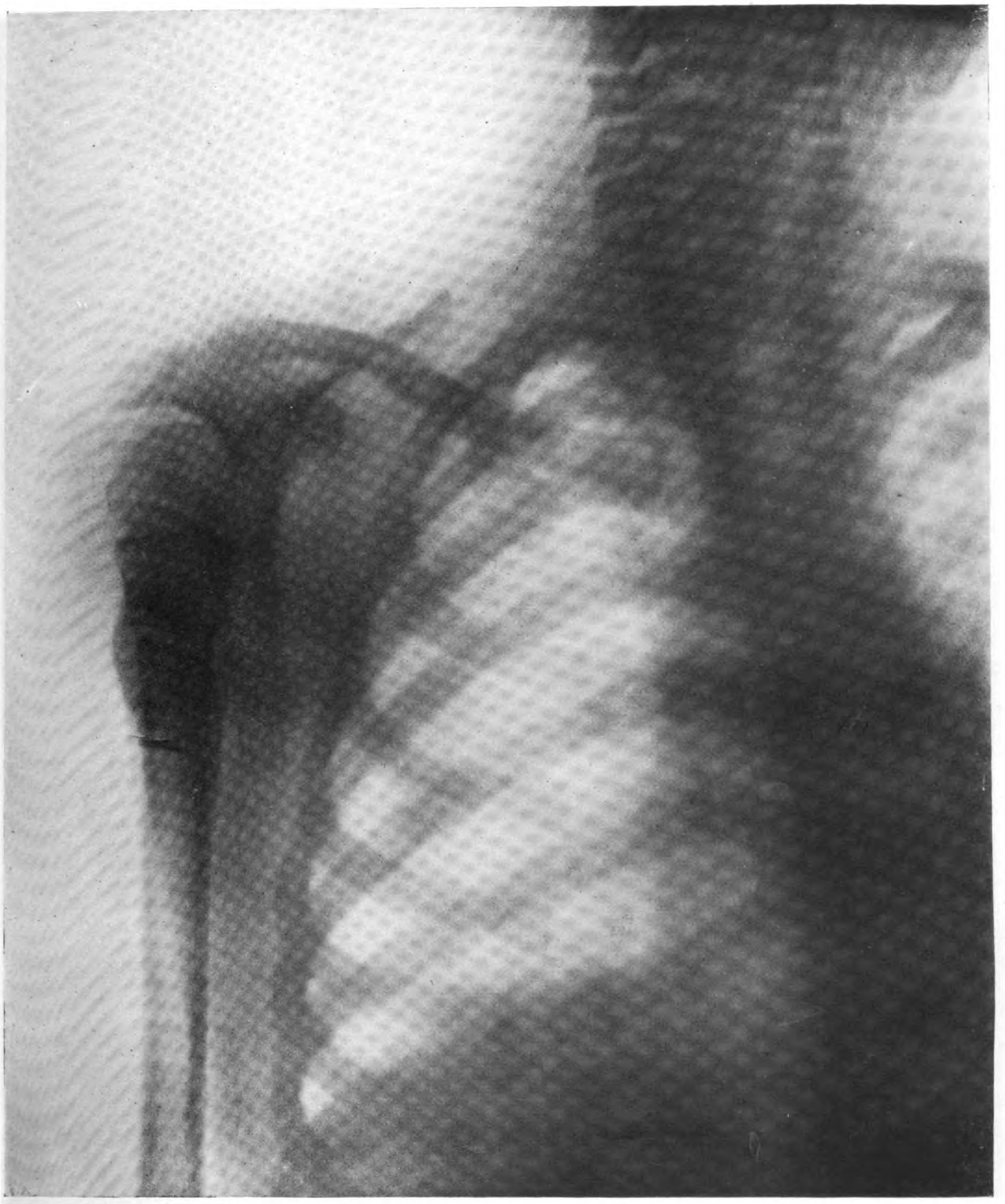


A CASE OF GENU VALGUM.

(By Mr. MARSDEN for S. C. MOORE, M.B., Liverpool.)

PLATE XLVI.

(*"Archives of the Roentgen Ray."—Copyright.*)

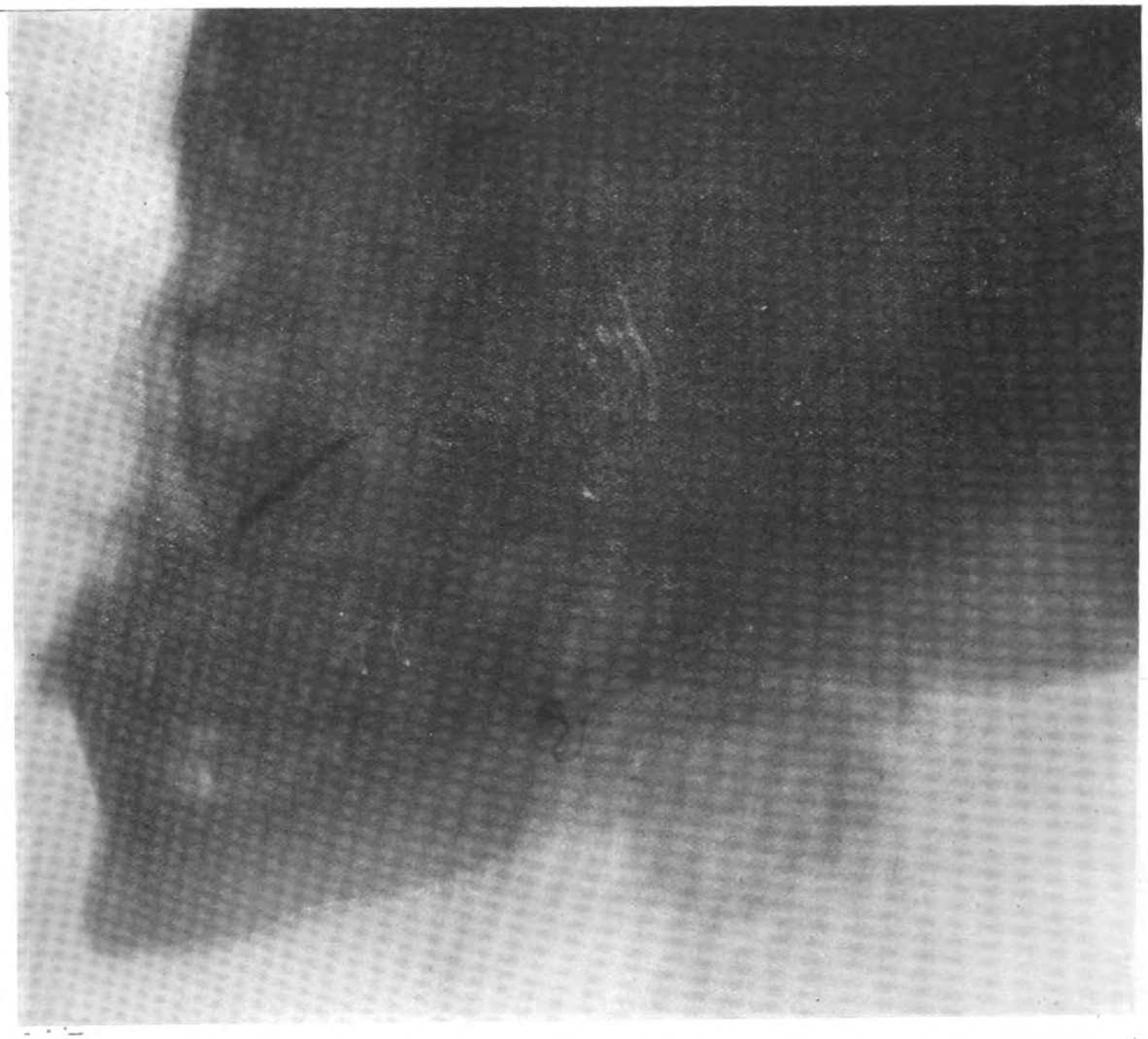


FRACTURE OF HUMERUS.

(By Dr. CARL BECK, New York.)

PLATE XLVII.

(*"Archives of the Roentgen Ray."—Copyright.*)



CASE OF TUBE IN ANTRUM OF HIGHMORE.

(By Dr. F. H. LOW, London.)

PLATE XLVIII. (*a*).

(*"Archives of the Roentgen Ray."—Copyright.*)

STEREOSCOPIC HAND.

(By W. S. HEDLEY, M.D.)

PLATE XLVIII. (*b*).

(*"Archives of the Roentgen Ray."—Copyright.*)

STEREOSCOPIC HAND.

(By W. S. HEDLEY, M.D.)

PLATE XLVIII. (*c*).

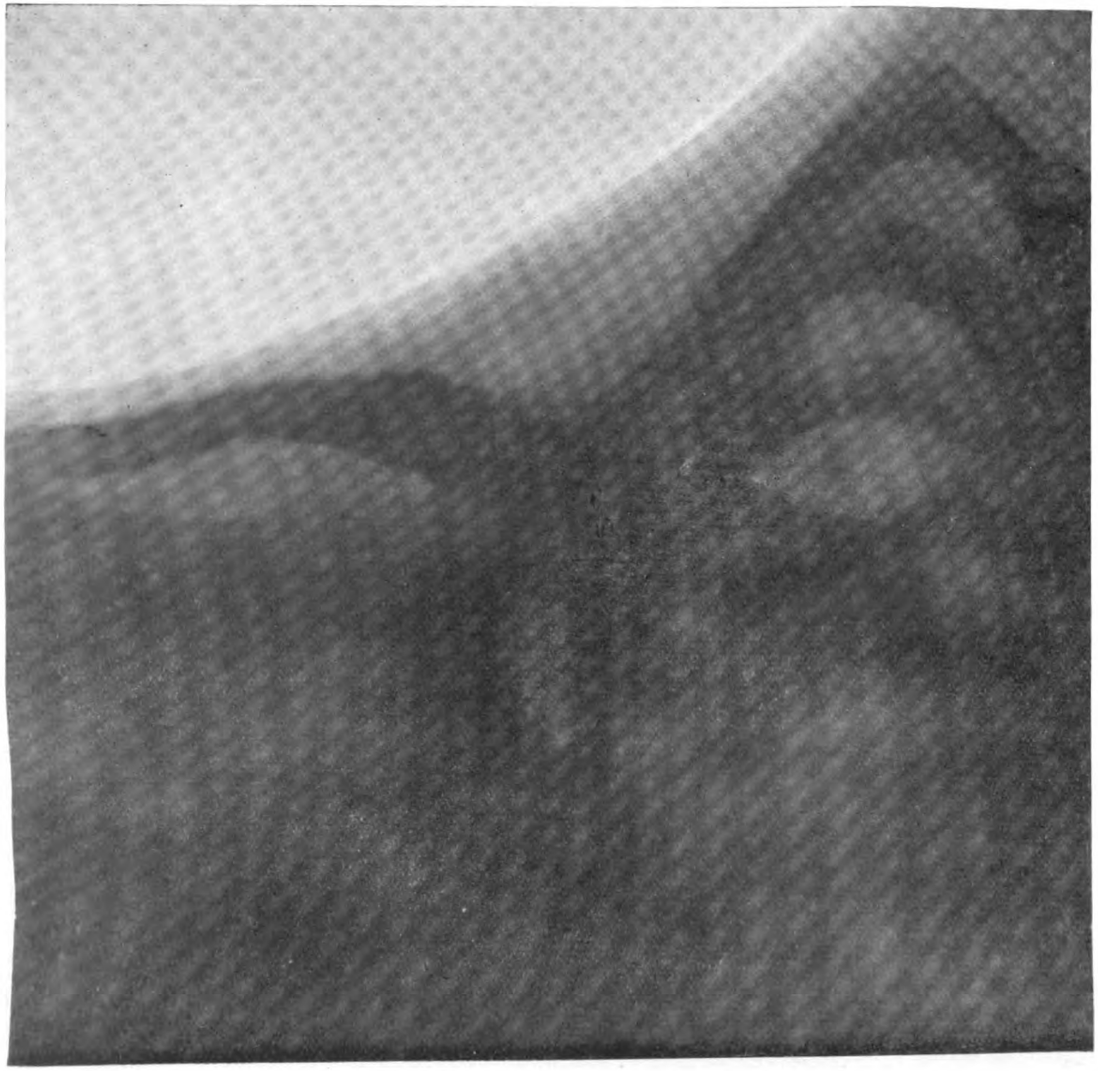
(*"Archives of the Roentgen Ray."—Copyright.*)

THREE FEMUR FRACTURES.

(*By* ERNEST PAYNE, *Brighton.*)

PLATE XLIX. (*a*).

("*Archives of the Roentgen Ray.*"—*Copyright.*)



MALFORMATION OF UPPER RIBS.

(*By HENRY A. ROOME, M.B., Southsea.*)

PLATE L. (*a*).

(*"Archives of the Roentgen Ray."—Copyright.*)

BULLET IN RIGHT FOOT.

(*By WILLIAM MARTIN, M.A., M.D., Newcastle-on-Tyne.*)

PLATE L. (*b*).

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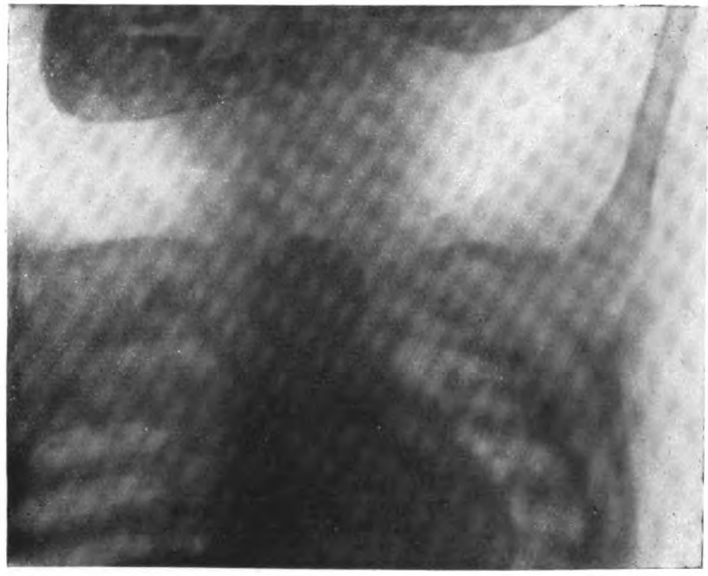

COIN IN THROAT.

(*By WILLIAM MARTIN, M.A., M.D., Newcastle-on-Tyne.*)

PLATE L. (*c*).

(*"Archives of the Roentgen Ray."—Copyright.*)

VOL. III.—No. 2.] NOVEMBER, 1898.

ARCHIVES

— OF —

THE ROENTGEN RAY

(*Formerly* ARCHIVES OF SKIAGRAPHY).

THE ONLY JOURNAL IN WHICH THE TRANSACTIONS OF THE ROENTGEN SOCIETY OF LONDON ARE OFFICIALLY REPORTED.

EDITED BY

THOMAS MOORE, F.R.C.S., AND ERNEST PAYNE, M.A. (CANTAB.),

Surgeon to the Miller Hospital. | *A.I.E.E.*

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1898.

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VOL. III.—No. 2.] NOVEMBER, 1898. [PRICE 4/- *or* $1.

ARCHIVES OF THE ROENTGEN RAY.

EDITORIALS.

Editors. WE regret that the issue of the present number of the ARCHIVES has been somewhat delayed in consequence of a change in the Editorship. Mr. Sydney Rowland, who was the originator of the publication, and one of the first to bring the new photography prominently before the medical profession in London, has accepted a post on the staff of the *British Medical Journal*. Dr. W. S. Hedley, who has so ably filled the Editorial Chair for the past eighteen months, has found his time too much occupied to continue the work. Our readers will be pleased to know that the knowledge and experience of the retiring Editors will not be lost to this journal, as they have both consented to act on the Editorial Committee.

British Association. We print in the present number an extract from Sir William Crookes' presidential address to the British Association referring to Roentgen Rays, and also an abstract of the discourse on Phosphorescence, by Mr. Herbert Jackson, the originator of the focus-tube. The discourse was illustrated by most brilliant experiments, many of which had never before been shown in public to a large audience.

Therapeutic Use of X Rays. We give also an abstract of papers by Dr. Albers-Schönberg and Dr. Hahn, of Hamburg, on the treatment of lupus and eczema by exposure to X rays. A case of lupus has recently been successfully treated in Liverpool by Dr. Thurston Holland. We believe this is the first case that has been successfully treated in England.

Conversazione. The Roentgen Society is to be congratulated on the successful conversazione given by the president, an account of which appears below. The exhibits of apparatus were quite up to date, and the work which is being done with the X rays was well illustrated by the large number of interesting radiographs sent in by the members of the society. We regret that it has been found quite impossible to give any detailed description of these, but it is to be hoped that many of them will be brought to the meetings of the society, where they may be inspected more closely. The suggestion in the report that meetings should be held for the special exhibition of apparatus and radiographs is one which will meet with wide approval.

THE ROENTGEN SOCIETY.

THE first Annual General Meeting of the Society was held at the rooms of the Medical Society, Chandos Street, Cavendish Square, on Tuesday, November 1st, Mr. THOMAS MOORE, F.R.C.S., Treasurer, in the chair. A letter was read from the President, Professor Silvanus P. Thompson, regretting his inability to attend in consequence of professional engagements away from town.

The following new Members were elected: Mr. J. T. Niblett, E.E.; Mr. H. Wagg; Mr. Hastings Stewart, M. R. C. S. And eight others were proposed, viz.: E. F. Mansell, M.D., Ashtead; C. G. Burton, M.R.C.S.; Allan Hair, M.R.C.S.; A. Lewis Stent, Havant; W. H. Haughton, M.B. Dublin; R. Milne Murray, M.D. Edinburgh; J. Barden Smith; Herbert Blundell.

The TREASURER then read his report, showing a balance of £46 8s. 5d. in favour of the Society, which was adopted with applause.

The Report of Council, which will be found on another page, was read by the SECRETARY, and adopted.

The SOCIETY then proceeded to the election of President and Officers for the ensuing year. Messrs. Wimshurst and Vezey were chosen scrutineers of the voting papers, and were able to announce that the list of Officers proposed by the Council had been unanimously adopted. The Council for 1898-99 will, therefore, be as follows:

President: C. W. Mansell-Moullin, M.D. Oxon., F.R.C.S.

Past President: Professor Silvanus Thompson, F.R.S.

Honorary Members: Professor Roentgen; Sir William Crookes, F.R.S., K.C.B.

Vice-Presidents: Lord Blythswood; Professor Ferrier, F.R.S.; J. H. Gladstone, Ph.D., F.R.S.; John Macintyre, M.B., F.R.S. Edin.; A. A. Campbell-Swinton; Professor Dawson Turner, M.D.

Council: Mackenzie Davidson, M.B.; F. E. Fenton, F.R.C.S.; J. E. Greenhill; W. S. Hedley, M.D.; A. W. Isenthal; F. H. Low, M.B.; Wilson Noble; Sydney Rowland, M.A., M.B.; J. J. Vezey; Snowden Ward; W. Webster, F.C.S.; Norris Wolfenden, M.D.

Hon. Treasurer: Thomas Moore, F.R.C.S., Lee Terrace, Blackheath, S.E.

Hon. Secretary: David Walsh, M.D., 5, Pump Court, Temple, E.C.

In introducing the new President to the meeting, the Chairman pointed out the prestige which the retiring President had given to the Society from his eminence in the scientific and electrical world, and hoped the Society would derive advantages as great under the new President, who occupies a very high position in the surgical world. Mr. Mansell-Moullin, besides being M.A. and M.D. of Oxford and a Fellow of the College of Surgeons, is surgeon and lecturer on surgery at the London Hospital (the largest in the Metropolis) and is the author of several valuable surgical works.

Mr. MANSELL-MOULLIN then took the chair, and, after eulogizing the past President for his eminent qualities and tact, remarked that the only fault he had to find with him was that he had made it very difficult for his successor to fill the chair with equal success. At the same time, he hoped that he might be able to do some good work for the Society, which occupied so wide a field. In offering a few suggestions for future work, he pointed out the great need of an atlas of normal osteology. This, he thought, might be drawn up under the authority of the Society. There are many common injuries and defects of the human body which could be well illustrated by the work of the Society; for instance, a great collection of radiographs of the varieties of Colles' fractures would be of special interest, also of congenital dislocations of the hip, of which there were many forms that were unknown until radiography was established. The hip being the most difficult part of the body to radiograph, the processes would have to be carried out most accurately and scientifically. The position of the tube, its distance from the plate, and the time of exposure should be accurately recorded in all cases. He alluded also to the possibilities of improvements in focus-tubes and photographic methods. In thanking the Society for the honour they had done him in electing him as President, he said he would do his best to make the work of the coming year as successful as that of the past.

The following new rule was proposed and adopted:

"That each retiring President shall become an ex-officio member of the Council for three years, and that his name appear on the list of officers as past President."

Votes of thanks were then proposed, and carried unanimously, to the past President and to the Treasurer and Secretary.

With reference to the Special Committee for collecting information as to the alleged injurious effects of X rays, Mr. E. PAYNE said that reports of six cases had been received by the Committee, and that five others had been promised. Though the number of cases reported did not supply sufficient data for drawing up any extensive report on the general question, there was sufficient material for an interesting discussion on the subject.

Mr. WILSON NOBLE made a generous offer of a 10-inch coil to the Society, which was most cordially accepted, and will doubtless prove to be of the greatest use for demonstrations at the Society's meetings.

THE ROENTGEN SOCIETY.

FIRST ANNUAL REPORT.

THE famous discovery of Professor Roentgen, announced at the latter end of 1895, gave a new stimulus to many branches of scientific investigation in all parts of the civilized world. Its practical bearing upon medical work was at once evident, no less than its relation to electricity and to photography. In this way it appealed to those engaged in the practice and theory of each of the above-mentioned subjects. In Great Britain its announcement excited a great amount of attention, as might be expected in a country where the classic experiments of Mr. (now Sir William) Crookes upon electrical discharges in high vacua were conducted years ago.

The history and development of Roentgen ray methods, however, need not detain us further here. In the first Annual Report which the Council of the Roentgen Society now have the honour of submitting to members

they propose to make a brief sketch of the origin of the Society and of its work during the past official year, together with a forecast of its future sphere of usefulness.

A committee of medical men, called by announcement in the medical journals, held a preliminary meeting on the 18th of March, 1897, when it was resolved to found a Society. Its original intention was to confine membership to medical men, but, after much discussion, that idea was abandoned. Its next important step may be gathered from the following paragraph, taken from the *British Medical Journal* of April 10th, 1897:

"At a meeting of medical men interested in the X rays held last week at 20, King William Street, Strand, rules were drawn up, subject to final approval at a large general meeting, on the lines common to most scientific societies. It was resolved that membership should not be restricted to medical men, but should include all who are interested in the scientific study of the Roentgen rays. The difficulty of discussing medical matters before a mixed audience will probably be got over by forming a medical subsection. Any inquiries may be made of the Honorary Secretary, Dr. Walsh, 5, Pump Court, Temple, E.C."

At this point the selection of a future President became necessary, and the provisional committee unanimously invited Professor Silvanus Thompson, who accepted the office. The name of the Society was altered to "Roentgen Society," and the first general meeting was held on June 3rd, 1897, at the Medical Society's rooms, 11, Chandos Street, Cavendish Square, W., under the presidency of Professor Thompson, who delivered an opening address. After the formal institution of the Society, the meeting proceeded to elect officers for the ensuing year, with the following result:

President: Professor Silvanus P. Thompson, D.Sc., F.R.S.

Vice-Presidents: Professor Ferrier, F.R.S.; J. H. Gladstone, Ph.D., F.R.S.; John Macintyre, M.B., F.R.S. Edin.; C. W. Mansell-Moullin, M.D., F.R.C.S.; J. Fletcher Moulton, Q.C., F.R.S.; Professor Dawson Turner.

Hon. Member: Professor Roentgen.

Council: Mackenzie Davidson, M.B.; F. E. Fenton, F.R.C.S.; J. E. Greenhill; W. S. Hedley, M.D.; F. H. Low, M.B.; T. Moore, F.R.C.S.; Sydney Rowland, M.A.; A. A. Campbell-Swinton; Snowden Ward; W. Webster, F.C.S.; R. Norris Wolfenden, M.D.

Hon. Sec.: David Walsh, M.D.

At a later date Mr. Moore was elected Treasurer for the year, and the full number of the Council completed by the election of Messrs. Isenthal and Vezey.

During the next few months several important resolutions were adopted by the Council. Ladies were declared eligible for membership; sections were considered inadvisable for the present; Sir William Crooke was added to the Honorary Members; and it was decided to inaugurate the Society with a conversazione. The publication of the proceedings of the Society next engaged the attention of the Council, and after careful negotiation an arrangement was entered into with the Rebman Company, publishers of the ARCHIVES OF THE ROENTGEN RAYS, late ARCHIVES OF SKIAGRAPHY. By the terms of the agreement, the official records of the Society were to be published quarterly in that journal, a copy of which was to be supplied to each member. The thanks of the Society are due to Edward Moore, Esq. (brother of the Honorary Treasurer), who was kind enough to give legal advice, and to draw up the documents connected with the above transactions, without expense to the Society.

The opening of the serious work of the Society may be said to date from the inaugural meeting held at St. Martin's Town Hall on the evening of November 5, 1897. On that occasion Professor Silvanus Thompson delivered an eloquent address to a large and distinguished audience. Among the objects of interest to members and visitors were screen demonstrations upon the living body by Messrs. Moore and Webster, when the "beating heart" was first shown in public; an extensive collection of Roentgen ray photographs (numbering some six or seven hundred) arranged by Mr. Snowden Ward; a collection and demonstration of apparatus of various kinds under Dr. Hedley; a lantern-room demonstration by Mr. Greenhill; and a fine show of various exhaust and display tubes, lent by Mr. Vezey and Mr. Cosser, under the charge of Dr. Fenton and Mr. Isenthal. Special objects of interest were the new induction coil of Nikola Tesla, shown by the President; a full-length focus-tube exposure by Dr. Morton, of New York; the localizing apparatus of Mr. Mackenzie Davidson; stereoscopic radiographs of an injected brain and other organs, by Dr. Hedley; transparencies by Dr. Walsh; and skiagrams of bullets detected by the new method during the Græco-Turkish War by Mr. F. C. Abbott; Mr. W. Webster showed a series of hands and arms taken in January, 1897, with exposures varying from one twenty-fifth to one second; also an adult trunk with good

detail, taken in three minutes. Mr. William Payne's photograph of lumbar spine was of unique excellence. An excellent selection of vocal and instrumental music was kindly arranged by Mr. Webster. The thanks of the Society are due to the gentlemen who carried out the laborious task of organizing the details of this most successful inaugural meeting.

The Work of the Society.

The work of the Society has been carried on at general meetings held monthly during the winter and the summer sessions. It has comprised the exhibition of Roentgen ray photographs, the reading of papers, and of discussion thereon. With regard to the photographs, many valuable contributions have been made by members both from town and from country. The scope of the papers, many of which were illustrated by lantern slides, may be gathered from the following list:

1897.

Nov. 5th. President's Inaugural Address on the Aims of the Society.

Dec. 7th. "On Adjustable Focus-tubes": A. A. Campbell-Swinton.

1898.

Jan. 11th. "Practical Work with the X Ray": W. Webster.

Feb. 1st. "Periosteal and other Soft Tissue Shadows": David Walsh, M.D.; "Localization": Mackenzie Davidson, M.B.

March 1st. "Photographic Activity and Penetration of Roentgen Rays at Different Vacua": J. H. Gardiner; "Some Observations on Various Makes of Tube, and Varying Conditions of Vacua": Wilson Noble.

April 5th. "The Influence Machine and its Advantages for Lighting X Ray Tubes": James Wimshurst, F.R.S.

May 10th. "Notes on the Description of a New Induction Coil": A. Apps, M.I.E.E.; "Some Notes on Contact-Breakers": J. Macintyre, M.B.

June 7th. "Work on the X Ray": T. C. Porter; "A Pinhole Roentgen Ray Camera and its Applications": A. A. Campbell-Swinton; "A Preliminary Communication on the Action of the X Ray on Micro-Organisms": Drs. Forbes Ross and Wolfenden.

The above papers, with the discussions thereon, are printed at length in THE ARCHIVES OF THE ROENTGEN RAY, the official organ of the Society.

While recognising the value of scientific papers, the Council feel that it would be desirable in the interest of members to hold from time to time informal meetings for the exhibition of apparatus and photographs, and for the interchange of views and experiences. It is hoped that the coming winter session will be provided with an organization for that end.

The financial position of the Society is satisfactory, and the Council herewith recommend the cordial adoption of the treasurer's report. The expenses of the year have been necessarily somewhat heavy, owing to the cost incident to the foundation of a young society. Notwithstanding that fact, however, the Honorary Treasurer is able to point to the extremely satisfactory balance of £46 8s. 5d., as duly attested by the honorary auditors, Messrs. Isenthal and Vezey.

The rules of the Society forbid the appointment of the same President for two years in succession. In considering the choice of a successor to Professor Silvanus Thompson, the Council have borne in mind the mixed scientific nature of the Society, and recommend for the post a distinguished surgeon, Mr. C. W. Mansell-Moullin, M.D. Oxon., F.R.C.S., one of the Vice-Presidents of the Society.

During the year a sub-committee has been formed to investigate the subject of "X Ray Dermatitis." The President, Dr. Barry Blacker, Mr. Thos. Moore, Dr. Walsh, and Mr. E. Payne were appointed, the last-mentioned gentleman to act as honorary secretary to the sub-committee.

A great mass of literature has sprung up around the Roentgen ray methods. Besides the English ARCHIVES OF THE ROENTGEN RAY, there is an excellent American X Ray journal, edited by Heber Roberts, M.D., of St. Louis; a French journal—*Les Rayons X*—edited by Dr. Bourgade la Dardye, of Paris; and a German publication, issued at Hamburg.

It is hoped that before long the Roentgen Society will have a permanent home for the housing of literature.

At the same time, such quarters would be available for the promotion of a gallery of Roentgen photographs of historic and general interest, and for a collection of apparatus. With regard to the last-mentioned point, the Council have to report that during the past session a donation of two guineas was offered by a member towards the cost of a coil for use at the Society's

meetings.* The Council will be pleased to accept any similar offers.

The roll of membership now amounts to 127, and includes members in America, Germany, Austria, India, the Cape, and Australia. There are three lady members, one a doctor, who is an enthusiast in Roentgen work. The Council have to announce with deep regret that one of the members has been removed by death in the person of Mr. C. N. Peal, F.L.S., late of Fernhurst, Ealing, W.

Signed on behalf of Council,

SILVANUS P. THOMPSON, *President.*
THOS. MOORE, *Hon. Treasurer.*
DAVID WALSH, *Hon. Secretary.*

ROENTGEN RAYS AT THE BRITISH ASSOCIATION.

Extract from Presidential Address

BY SIR WILLIAM CROOKES, F.R.S.

IN the mechanical construction of Roentgen ray tubes I can record a few advances, the most successful being the adoption of Professor Silvanus P. Thompson's suggestion of using for the anti-cathode a metal of high atomic weight. Osmium and iridium have been used with advantage, and osmium anti-cathode tubes are now a regular article of manufacture. As long ago as June, 1896, X ray tubes with metallic uranium anti-cathodes were made in my own laboratory, and were found to work better than those with platinum. The difficulty of procuring metallic uranium prevented these experiments from being continued. Thorium anti-cathodes have also been tried.

Roentgen has drawn fresh attention to a fact very early observed by English experimenters—that of the non-homogeneity of the rays, and the dependence of their penetrating power on the degree of vacuum; rays generated in high vacua have more penetrative power than when the vacuum is less high. These facts are familiar to all who have exhausted focus tubes on their own pumps. Roentgen suggests a convenient phraseology; he calls a low vacuum tube which does not emit the highly penetrating rays a "soft" tube, and a tube in which the exhaustion has been pushed to an extreme degree, in which highly penetrating rays predominate, a "hard" tube. Using a "hard" tube, he took a photograph of a double-barrelled rifle, and showed not only the leaden bullets within the steel barrels, but even the wads and the charges.

Benoit has re-examined the alleged relation between density and opacity to the rays, and finds certain discrepancies. Thus, the opacity of equal thicknesses of palladium and platinum are nearly equal, whilst their densities and atomic weights are very different, those of palladium being about half those of platinum.

At the last meeting of the British Association visitors saw, at the McGill University, Professors Cox and Callendar's apparatus for measuring the velocity of Roentgen rays. They found it to be certainly greater than 200 kilometres per second. Majorana has made an independent determination, and finds the velocity to be 600 kilometres per second, with an inferior limit certainly of not less than 150 kilometres per second. It may be remembered that J. J. Thomson has found for cathode rays a velocity of more than 10,000 kilometres per second, and it is extremely unlikely that the velocity of Roentgen rays will prove to be less.

Trowbridge has verified the fact, previously announced by Professor S. P. Thompson, that fluor-spar, which by prolonged heating has lost its power of luminescing when re-heated, regains the power of thermo-luminescence when exposed to Roentgen rays. He finds that this restoration is also effected by exposure to the electric glow discharge, but not by exposure to ultra-violet light. The difference is suggestive.

As for the action of Roentgen rays on bacteria, often asserted and often denied, the latest statement, by Dr. H. Rieder, of Munich, is to the effect that bacteria are killed by the discharge from "hard" tubes. Whether the observation will lead to results of pathologic importance remains to be seen. The circumstance that the normal retina of the eye is slightly sensitive to the rays is confirmed by Dorn and by Roentgen himself.

The essential wave-nature of the Roentgen rays appears to be confirmed by the fact ascertained by several of our great mathematical physicists that light of excessively short wave-length would be but slightly absorbed by ordinary material media, and would not in the ordinary sense be refracted at all. In fact, a theoretic basis for a comprehension of the Roentgen rays had been propounded before the rays were discovered. At the Liverpool meeting of the British Association several speakers,

* Mr. Wilson Noble, who made the offer, has since generously presented the Society with a 10-inch coil and a secondary battery.

headed by Sir George Stokes, expressed their conviction that the disturbed electric field caused by the sudden stoppage of the motion of an electrically charged atom yielded the true explanation of the phenomena extraneous to the Crookes high vacuum tubes—phenomena so excellently elaborated by Lenard and by Roentgen. More recently Sir George Stokes has re-stated his "pulse" theory, and fortified it with arguments which have an important bearing on the whole theory of the refraction of light. He still holds to their essentially transverse nature, in spite of the absence of polarization, an absence once more confirmed by the careful experiments of Dr. L. Graetz. The details of this theory are in process of elaboration by Professor J. J. Thomson.

Meantime, while the general opinion of physicists seems to be settling towards a wave or ether theory for the Roentgen rays, an opposite drift is apparent with respect to the physical nature of the cathode rays; it becomes more and more clear that cathode rays consist of electrified atoms or ions in rapid progressive motion. My idea of a fourth state of matter, propounded in 1881,* and at first opposed at home and abroad, is now becoming accepted; it is supported by Professor J. J. Thomson.† Dr. Larmor's theory‡ likewise involves the idea of an ionic substratum of matter; the view is also confirmed by Zeeman's phenomenon. In Germany, where the term "cathode ray" was invented almost as a protest against the theory of molecular streams propounded by me at the Sheffield meeting of the British Association in 1879, additional proofs have been produced in favour of the doctrine that the essential fact in the phenomenon is electrified radiant matter.

The speed of these molecular streams has been approximately measured, chiefly by aid of my own discovery, nearly twenty years ago, that their path is curved in a magnetic field, and that they produce phosphorescence where they impinge on an obstacle. The two unknown quantities, the charge and the speed of each atom, are measurable from the amount of curvature and by means of one other independent experiment.

It cannot be said that a complete and conclusive theory of these rays has yet been formulated. It is generally accepted that collisions among particles, especially the violent collisions due to their impact on a massive target placed in their path, give rise to the interesting kind of extremely high frequency radiation discovered by Roentgen. It has, indeed, for some time been known that whereas a charged body in motion constitutes an electric current, the sudden stoppage, or any violent acceleration of such a body, must cause an alternating electric disturbance, which, though so rapidly decaying in intensity as to be practically "dead beat," yet must give rise to an ethereal wave or pulse travelling with the speed of light, but of a length comparable to the size of the body whose sudden change of motion caused the disturbance. The emission of a high-pitched musical sound from the jolting of a dustman's cart (with a spring bell hung on it) has been suggested as an illustration of the way in which the molecules of any solid not at absolute zero may possibly emit such rays.

If the target on to which the electrically-charged atoms impinge is so constituted that some of its minute parts can thereby be set into rhythmical vibration, the energy thus absorbed reappears in the form of light, and the body is said to phosphoresce. The efficient action of the phosphorescent target appears to depend as much on its physical and molecular as on its chemical constitution. The best-known phosphori belong to certain well-defined classes, such as the sulphides of the alkaline-earthy metals, and some of the so-called rare earths; but the phosphorescent properties of each of these groups are profoundly modified by an admixture of foreign bodies—witness the effect on the lines in the phosphorescent spectrum of yttrium and samarium produced by traces of calcium or lead. The persistence of the samarium spectrum in presence of overwhelming quantities of other metals, is almost unexampled in spectroscopy; thus one part of samaria can easily be seen when mixed with three million parts of lime.

Without stating it as a general rule, it seems as if, with a non-phosphorescing target, the energy of molecular impact reappears as pulses so abrupt and irregular that, when resolved, they furnish a copious supply of waves of excessively short wave-length—in fact, the now well-known Roentgen rays. The phosphorescence so excited may last only a small fraction of a second, as with the constituents of yttria, where the duration of the different lines varies between the 0·003 and the 0·0009 second; or it may linger for hours, as in the case of some of the yttria earths, and especially with the earthy sulphides, where the glow lasts bright enough to be commercially useful. Excessively phosphorescent

* *Phil. Trans.*, Part II., 1881, pp. 433, 434.
† *Phil. Mag.*, October, 1897, p. 312. ‡ *Ibid.*, December, 1897, p. 506.

bodies can be excited by light waves, but most of them require the stimulus of electrical excitement.

It now appears that some bodies, even without special stimulation, are capable of giving out rays closely allied, if not in some cases identical, with those of Professor Roentgen. Uranium and thorium compounds are of this character, and it would almost seem from the important researches of Dr. Russell that this ray-emitting power may be a general property of matter, for he has shown that nearly every substance is capable of affecting the photographic plate if exposed in darkness for sufficient time.

No other source for Roentgen rays but the Crookes tube has yet been discovered, but rays of kindred sorts are recognised. The Becquerel rays, emitted by uranium and its compounds, have now found their companions in rays—discovered almost simultaneously by Curie and Schmidt—emitted by thorium and its compounds. The thorium rays affect photographic plates through screens of paper or aluminium, and are absorbed by metals and other dense bodies. They ionise the air, making it an electrical conductor, and they can be refracted and probably reflected—at least, diffusively. Unlike uranium rays, they are not polarized by transmission through tourmaline, therefore resembling in this respect the Roentgen rays.

Quite recently M. and Mdme. Curie have announced a discovery which, if confirmed, cannot fail to assist the investigation of this obscure branch of physics. They have brought to notice a new constituent of the uranium mineral pitchblende, which in a 400-fold degree possesses uranium's mysterious power of emitting a form of energy capable of impressing a photographic plate and of discharging electricity by rendering air a conductor. It also appears that the radiant activity of the new body, to which the discoverers have given the name of polonium, needs neither the excitation of light nor the stimulus of electricity; like uranium, it draws its energy from some constantly regenerating and hitherto unsuspected store, exhaustless in amount.

It has long been to me a haunting problem how to reconcile this apparently boundless outpour of energy with accepted canons; but, as Dr. Johnstone Stoney reminds me, the resources of molecular movements are far from exhausted. There are many stores of energy in nature that may be drawn on by properly constituted bodies without very obvious cause. Some time since I drew attention to the enormous amount of locked-up energy in the ether; nearer our experimental grasp are the motions of the atoms and molecules, and it is not difficult mentally so to modify Maxwell's demons as to reduce them to the level of an inflexible law, and thus bring them within the ken of a philosopher in search of a new tool. It is possible to conceive a target capable of mechanically sifting from the molecules of the surrounding air the quick from the slow movers. This sifting of the swift-moving molecules is effected in liquids whenever they evaporate, and in the case of the constituents of the atmosphere, wherever it contains constituents light enough to drift away molecule by molecule. In my mind's eye I see such a target as a piece of metal cooler than the surrounding air acquiring the energy that gradually raises its temperature from the outstanding effect of all its encounters with the molecules of the air about it. I see another target of such a structure that it throws off the slow-moving molecules with little exchange of energy, but is so influenced by the quick-moving missiles that it appropriates to itself some of their energy. Let uranium or polonium, bodies of densest atoms, have a structure that enables them to throw off the slow-moving molecules of the atmosphere, while the quick-moving molecules, smashing on to the surface, have their energy reduced and that of the target correspondingly increased. The energy thus gained seems to be employed partly in dissociating some of the molecules of the gas (or in inducing some other condition which has the effect of rendering the neighbouring air in some degree a conductor of electricity), and partly in originating an undulation through the ether, which, as it takes its rise in phenomena so disconnected as the impacts of the molecules of the air, must furnish a large contingent of light waves of short wave-length. The shortness in the case of these Becquerel rays appears to approach without attaining the extreme shortness of ordinary Roentgen rays. The reduction of the speed of the quick-moving molecules would cool the layer of air to which they belong; but this cooling would rapidly be compensated by radiation and conduction from the surrounding atmosphere. Under ordinary circumstances, the difference of temperature would scarcely be perceptible, and the uranium would thus appear to perpetually emit rays of energy with no apparent means of restoration.

The total energy of both the translational and internal motions of the molecules locked up in quiescent air at ordinary pressure and temperature is about 140,000 foot-

pounds in each cubic yard of air. Accordingly, the quiet air within a room 12 feet high, 18 feet wide, and 22 feet long contains energy enough to propel a one-horse engine for more than twelve hours. The store drawn upon naturally by uranium and other heavy atoms only awaits the touch of the magic wand of Science to enable the twentieth century to cast into the shade the marvels of the nineteenth.

PHOSPHORESCENCE.

(Abstract of a Discourse before the British Association by Mr. Herbert Jackson.)

After noticing the work already done by Becquerel, Stokes, and Crookes, the lecturer pointed out that phosphorescent phenomena may be divided into two main classes, those in which the evolution of light is associated with chemical change, and those in which there is no evidence of such direct alteration. Examples of the first kind are numerous, such as phosphorus, sodium, potassium, etc., but as the experimental illustration of these is not suitable for a large audience, those of the second class were chiefly dealt with. Experiments were carried out showing the light given out by the mineral chlorophane when heated, the phosphorescence in a Crookes tube and phosphorescence under X rays.

In dealing with the whole subject of phosphorescence it is convenient to consider (*a*) the nature of the substance giving out the light; (*b*) the nature of the light itself; (*c*) the nature of the exciting causes.

As to the nature of the light given out, it is noticeable that the colours of the phosphorescence bear a close resemblance to the colours of the lines and bands seen in the various spectra of the different metals and some of their compounds. Phosphorescent compounds of the same substance in apparently the same state of purity give different colours. Confining attention to lime, separate specimens prepared from a great many calcium salts appear to show that they may preserve in the solid state some relation in their own molecular complexity to that of the salts from which they were obtained; some specimens, selected out of 350, phosphoresced red, some orange-red, some orange, others green, and some blue. These were shown by the aid of electric discharge in a high vacuum.

Before trying to show the points in common between these and the phenomena of phosphorescence in other conditions, the character of the action in a high vacuum should be considered.

When a discharge passes through a partial vacuum, there can be little doubt that the transferring medium is the residuum of gas in it. If the particles of this gas behave as visible masses are seen to do, they are probably attracted or are driven to the electrode, which is at high potential. Receiving the same kind of charge as this electrode, they fly off from it in that charged condition.

But if these particles consist of more than one unit, each unit, after the group has travelled a certain distance from the electrode, must repel each other unit in the same way as the whole little group was repelled from the electrode. If, however, the units making up the group are held together by that something which is called "chemical attraction," a condition of strain is set up in which the electrical repulsion is striving to overcome the chemical attraction. Travelling unimpeded through the high vacuum, this condition of strain would be maintained until the charged group met with something capable of discharging it. At that moment of discharge the chemical attraction would assert itself; there would be a rushing together of the units composing the group, and an "over-rushing," whereby oscillations would be set up. These oscillations, considered as blows or pulses, either directly or ethereally transferred to a substance, would set it in turn oscillating in a manner fitted to its own molecular structure, and its oscillations would in their turn give rise to the undulations which appeal to our eyes as the phosphorescent light. If, instead of the discharge taking place on a substance capable of responding to and absorbing most of the energy of the consequent oscillations, it were to occur on glass, platinum, or any of the materials which have been employed, it is conceivable that the oscillations would appear as short ethereal waves, or, in other words, Roentgen rays. In the case of a low vacuum or no vacuum at all, the charged particles would discharge themselves against the intervening gas, which would in its turn respond to the rapid oscillation and give out its own particular coloured light. The expression "short ethereal waves" is used intentionally, for if there should be forthcoming experimental evidence of the complex molecular structure of a gas, it is reasonable to suppose that in a high vacuum, with consequently a high potential at the electrode, the internal repulsion in a group would tend to a dissociation, resulting finally

in the simplest form of system capable of separate existence in those conditions. It might be expected that the oscillation-frequency of so simple a system would be very high.

Here it may be stated that this comes practically to the same thing as Sir William Crookes' original conception of radiant matter.

Leaving the method of electrical excitation *in vacuo*, and turning to light as a source of oscillations, phosphorescent effects are produced by the light of the sun, of the electric arc, of a hydrogen flame, and of many other substances in a state of vigorous combustion. The best light for inducing the phosphorescence is the spark from a coil, with a Leyden jar in circuit. Different forms of lime, when exposed to the jar-spark, yield their specially-coloured phosphorescent glows as in the vacuum tubes.

In regard to the question how far one and the same light—*i.e.*, one and the same oscillation frequency—will excite the different specimens of lime, a complete answer cannot be given. A lime prepared from calcium urate shows an orange phosphorescence; if glass, mica, or Iceland spar be placed between the lime and the source of light, the effect of heat is to intensify greatly a phosphorescence of a blue colour. This blue is there before, but masked by the brilliancy of the orange colour. It is further possible to make a specimen of lime give an orange glow in a moderate vacuum while a portion of the same specimen is exhibiting a blue glow in a high vacuum.

With regard to the duration of the phosphorescence, the different behaviours of substances can perhaps be best brought under one explanation by applying the idea of a statical charge or a condition of strain to the phosphorescent substances themselves. Duration of phosphorescence would then be a measure of rapidity of discharge.

If it be supposed that, the strain having been set up in the particles of a substance, these discharge themselves against one another, or rather against uncharged particles, then a substance with great freedom of transference of movement among its particles would fail to show any sign of phosphorescence, since the strain would be released or conducted away by rapid transference before a condition could be set up out of which oscillations of sufficient amplitude could arise. With rather less freedom of movement among the particles the nonconducting state might be reached by restricting the extent of that movement by cold, as in Professor Dewar's experiment. Still less freedom of exchange may be considered to obtain in Balmain's luminous paint, and even less in the limes, which require heating to show up their phosphorescence; while in the case of the chlorophane and many other minerals the condition of strain, however set up, can apparently be retained indefinitely. The effect of heat in rendering a substance a better conductor can be well studied with pure substances *in vacuo* under the electric discharge.

Under the vigorous bombardment of radiant matter the temperature of the substance rises. In some substances this leads to an increase in the brilliancy of the glow maintained often even when the heating is very considerable; in others the hotter portions are marked out by a complete absence of phosphorescence. Observation seems to favour the conjecture that this absence is in many cases to be explained on the hypothesis that the heat endows the molecules with such freedom as to practically render them uninsulated.

Returning to the sources of oscillations, there is that of chemical action. The flame of coal-gas burnt in a Bunsen burner will excite phosphorescence in many specimens of lime. It is possible to obtain chemical combination in the presence of many bodies of a porous nature without any very marked heating effect. A jet of unlighted coal-gas allowed to play over warm porous lime produces a slight phosphorescence, visible in a dark room. By dusting easily volatile substances, such as finely-powdered resin, over slightly heated lime, the oxidizable vapour is brought more closely into contact with the lime and phosphorescence is visible. Experiments with many substances used in a similar way to the mantles of the incandescent gas-lights indicate that in addition to the ordinary heating effect there is another and a phosphorescent effect which probably precedes the ordinary hot stage. This phosphorescence can be seen if the mantles are introduced into a tube and treated with an electric discharge in high vacuum.

The attempt has been made to connect together all the phenomena of phosphorescence with a view of showing between them a likeness in kind. It is believed, then, that the following typical examples of the various phenomena which are described as phosphorescent phenomena are similar in kind, and can be related to one another by the application of slight modifications of the same general principle—the glow of phosphorus, the fluorescence of quinine, the sparkling

of heated chlorophane, the luminosity of Balmain's paint, the light from lime in a vacuum tube, and the glowing of barium platinocyanide under the influence of X rays. To these it is proposed to add coloured flames and the spectral light of glowing gases. It is suggested that all these phenomena may be looked upon as outward evidences of response on the part of the substances to rapid oscillations, whether these oscillations have their origin in chemical combination in what is commonly spoken of as light, or in electrical discharge. The nature of that response may in some cases be of a direct character; but when account is taken of the many degrees of persistence of phosphorescence and of potential phosphorescence, it seems in many cases just to assume the form of something which, to avoid circumlocution, may be called a statical charge. The release of this condition of strain is accompanied by oscillations which give rise to the visible undulations of the phosphorescent light.

A SIMPLE AND INEXPENSIVE METHOD OF LOCALIZING WITH X RAYS.

By WILLIAM JAMES FLEMING, M.D.

A NUMBER of workers have devised methods of localizing buried objects which cast shadows with X rays. Probably the best is Dr. Mackenzie Davidson's, and with it most accurate results can be obtained; but, like all the others which I have seen described, it is elaborate, cumbrous, and expensive. All the methods are based on the measurement of the distance apart at which two images of the object are produced by rays impinging upon it in two directions at known angles to each other. In trying to arrive at this by simply moving the focus tube in the ordinary holder to definite distances on each side of the perpendicular passing through the object, I found the great difficulty lay in the fact that the tube had to be rotated upon both its axes in order to make the slanting surface of the anode face in the desired direction. When the tube is held in the usual manner in a clamp, this requires so much measurement and adjustment that a large element of uncertainty is introduced. The small holder which I am about to describe gets over this difficulty by enabling the tube to be rotated on two axes crossing at the centre of the anode, the point from which the rays proceed, and in this way avoiding any alteration of the distance of this point from the plane of the surface of the sensitive plate.

As may be seen from the diagram, the holder consists of one vertical and two horizontal arms, the horizontal arms coming off at right angles, at the ends and opposite

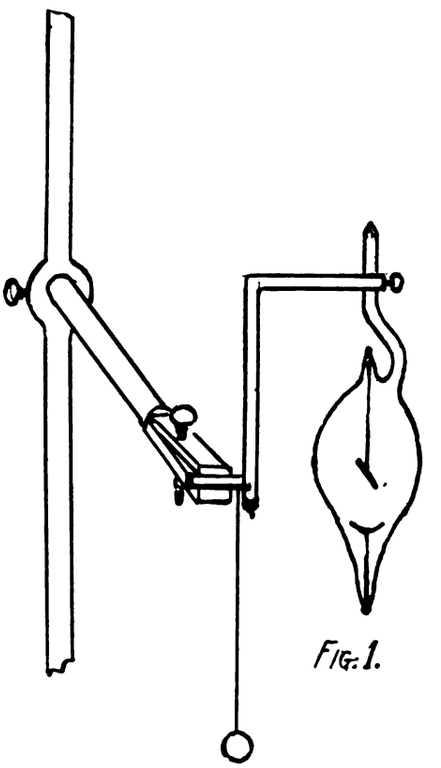

FIG. 1.

sides of the vertical. The one horizontal arm is perforated near its extremity from above down by a hole large enough to take the neck of the tube, and provided with a pinch screw to fix it. The other horizontal arm consists of a short piece of small brass tube open at both ends passed through the vertical bar and firmly fixed in it. This brass tube is held in the jaws of an ordinary wooden tube-stand.

A plumb-line is dropped from the brass tube.

With this simple appliance* sufficiently accurate results may be got. The method of employing it is as follows: The neck of the tube to be used is passed through the hole in the long arm, and adjusted so that, on looking through the brass tube, the centre of the anode is found to be opposite the centre of the brass tube. The neck is then fixed by the pinch-screw, and its exact position marked upon the stem with ink or

* Made for me by Messrs. Baird and Tatlock.

a morsel of gummed paper. The brass tube is now clamped in the jaws of the holder, care being taken that it is horizontal. The plumb-line is adjusted to the distance at which it is proposed to place the anode from the plate during the exposure, and this distance is carefully noted. The vertical position of the object having been previously ascertained by one or more photographs with an opaque object placed in known position on the surface, the tube is adjusted at whatever distance may be judged best from this vertical position, and by rotating the tube in the hole in the upper arm, and then rotating the tube and holder in the jaws of the stand, the surface of the anode can be faced in the desired direction. The point immediately below the plummet is now carefully marked on a sheet of paper laid below the photographic plate and extending considerably beyond it. Upon this has previously been marked a line outside the plate which, if prolonged, would pass directly under the object. After the first exposure is made, the tube is moved by lifting the stand until the plummet falls at the same distance on the other side of this line. This position is also marked on the paper. The anode is adjusted, and a second exposure made. Care must be taken that the positions of the horizontal

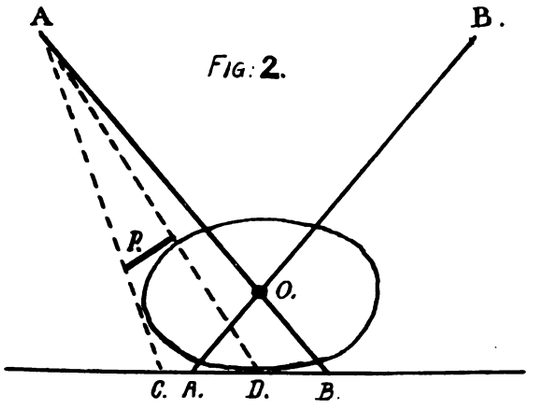

FIG. 2.

arm of the stand at the times of exposure are parallel to each other. With a little practice it is now possible to place a flat piece of metal in such a position that the portion of the plate to receive the one exposure is protected from the rays during the other. This may be seen from Fig. 2. When the anode is in the position A, the surface, *C D*, between the dotted lines is protected by the Plate P, and upon this portion of the sensitive film will fall the image when the anode is placed at B. The metal plate, being adjusted on the other side, protects the image already made during the second exposure from B. After the plate is developed, a sheet of paper

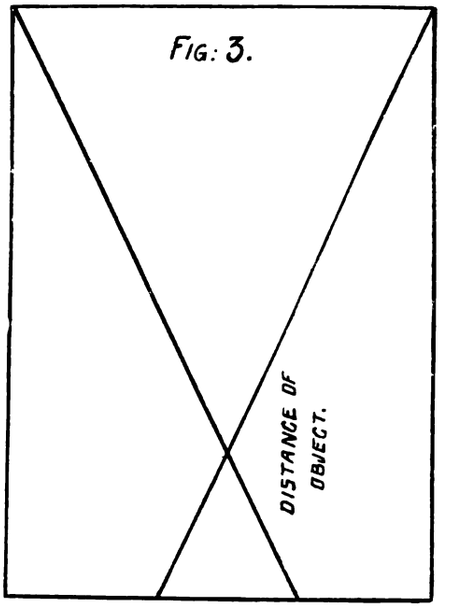

FIG. 3.

is taken. Upon it is drawn a parallelogram of which the sides are exactly the length of the plumb-line—that is to say, the distance of the anode from the sensitive plate—and the top and bottom the length through which the tube was moved, as recorded by the marks showing the position of the plummet. The distance of the two images from each other is carefully measured and marked on the centre of the base line, and a line drawn to each of these points from the opposite angle of the parallelogram. The place of their intersection is the distance of the object from the *sensitive film.*

THE TREATMENT OF LUPUS.

AT a meeting of the Deutscher Naturforscher und Arztc at Dusseldorf, Dr. Albers-Schönberg read a paper on the treatment of lupus with X rays. After describing the different experiments carried out by other workers, he gave particulars of nine cases which had undergone successful treatment in his laboratory. The same apparatus was employed for all the cases described—a battery of 30 volts and spark length of 15 cm. The applications lasted for about half an hour each day, with interruptions of different amounts in the different cases.

In all cases the effects produced follow more or less

the same course. The skin first shows a slight yellow tint, which is soon followed by general redness of the affected part. This redness deepens in colour, and with some patients a slight itching and pricking sensations are felt, together with a feeling of warmth. A sensation of tightness of the skin also follows in some cases, with slight œdema.

Excoriation is generally produced, the appearance resembling that of a burn, and extends up to the edges of the area protected by the mask. The skin gradually heals from the edges towards the centre.

To protect the parts not to be "rayed" a mask of cardboard is used, covered with tin-foil, which is more convenient than a lead protection, especially when dealing with the face.

As soon as the redness begins to show itself the sittings should be discontinued, and it is important to keep a close watch on the effects produced during the first applications, to avoid, if possible, a general dermatitis which hinders the cure.

The following is a brief summary of the cases described:

1. Miss M., age 53. Lupus of left cheek. Under medical treatment since 1870. Applications of X rays, with intervals, for six months.
2. Mr. R., age 20. Nose and upper lip. Medical treatment since 1895. One hundred and fifty-one applications of rays, spread over eight months.
3. Mrs. R., age 48. Nose and right cheek. Hospital treatment for two years. Applications of rays spread over six months.
4. A. K. (boy), age 13. Nose and upper lip affected for four years previously. Twenty-eight applications of rays during three months.
5. Miss B., age 37. Suffered from lupus of nose since 12 years of age. Forty-six applications during three months.
6. Miss W., age 27. Small spots on both cheeks and forehead. Under treatment for four years previously. Eleven applications during one month.
7. Miss N., age 18. Lupus faciei. No previous treatment. X rays applied during two months, fifteen times to left cheek and nose, ten times to right cheek.
8. Miss K., age 46. Upper lip, nose, and both cheeks affected. Under treatment for twenty-three years. Left cheek treated with X rays. Sixteen applications, spread over two months.
9. Miss K., age 36. Both cheeks and nose affected. Medical treatment for eleven years previously. Sixty-eight applications of rays.

(*Fortschritte der Röntgenstrahlen, II.* 20.)

THE TREATMENT OF ECZEMA AND LUPUS WITH X RAYS.

At a meeting of the Medical Society of Hamburg, on July 19th, Dr. R. Hahn described two cases of chronic eczema which had been successfully treated with X rays. The treatment had been carried out under the supervision of Dr. Albers-Schönberg, at the laboratory of the latter in Hamburg.

Both were cases of women suffering from eczema of the thigh, one for four years, the other for two. Various methods of treatment had been previously tried without any beneficial result. In the first case a cure was affected after twelve applications of the rays, without any injurious effects. In the second case, after four applications of the rays, redness of the part affected appeared, followed by slight œdema, which healed in three days after treatment with Goulard's lotion. The application of the rays was then continued, and a cure resulted.

(*Fortschritte der Röntgenstrahlen, II.* 16.)

THE INFLUENCE OF X RAYS ON ARTIFICIAL TUBERCULOSIS.

In the *Archives d'Électricité Médicale* for October, 1898, is an interesting article, by Messrs. Rodet and Bertin-Sans, on the above subject, in which they give the results of a series of experiments carried out in the Micro-biological and Physical Laboratory at Montpelier.

In the first place they quote the conclusions of several other observers on the influence of X rays on cultures of Koch's bacillus, all but one of whom assert that the effects are negative.

Then they allude to the experiments of many workers on their effects on animals inoculated with the bacillus. As these appeared to be contradictory, they proceeded to make further experiments for themselves.

They relate in detail the results of four series of experiments made on guinea-pigs, which were inoculated in the skin of the thigh—in the first series with

cultivations of the bacillus taken from a test-tube, and in the others with tuberculous matter from animals already affected with tubercle.

In each experiment some of the animals inoculated were treated by X rays, and others were left untreated, to serve as "controls."

The conditions of treatment were varied, as regards the intensity of the current employed, the duration of the séances and the position of the tube with regard to the animal.

The authors made no attempt to separate the effects of the X rays from those of the electric field generated by the vacuum tubes.

No curative effects on the disease were noticed during the course of the experiments, and we quote them mainly from their bearing on the production of dermatitis by exposure of the skin to X rays, on which subject a committee of the Roentgen Society is at the present time engaged in making investigations.

In *Experiment I.* two guinea-pigs were inoculated with human tuberculous lung. Forty-nine days afterwards, when the disease was fully established, one of them was submitted to treatment.

The animal was fastened on its back to a board, and the tube was placed at a distance of from 20 to 25 cm. above the inoculated part, with nothing intervening between it and the skin. Six séances a week were given, each of fifteen minutes' duration. On the whole there were sixty-four applications of the rays, with a total duration of forty hours.

After fifteen exposures the operations had to be suspended, in consequence of "local trophic troubles," viz., the falling off of hairs and ulceration like a burn. A week afterwards they were resumed. Seventeen exposures were given with the tube placed over the back of the animal, followed by twenty during which the tube was placed under a thin board on which it was seated. No dermatitis resulted, although the tube was approached to within 15 cm.

In *Experiment II.* two guinea-pigs were inoculated with tuberculous matter from a dead animal. Treatment was commenced thirty-five days afterwards, and was exactly similar to that carried out in Ex. I., with the same results.

Experiment III.—Treatment commenced two days after inoculation on two guinea-pigs. They received six exposures as in Ex. I. Then they were put into a wicker basket, and given twelve exposures with the tube 25 to 30 cm. distant, above their backs. Lastly, the tube was placed under the basket, and the animals received the rays twelve times through its bottom, and through a thin board placed under them.

One of these guinea-pigs was submitted to sixty-nine séances, which had a total duration of twenty-four hours; and the other to sixty-six, with a duration of six and a quarter hours. No local mischief was apparent.

Experiment IV.—Six inoculated guinea-pigs were treated, three as in Ex. I., with the tube directly over the points of inoculation, at 20 cm. distance. After twenty-three exposures serious local mischief appeared. The others were exposed through the bottom of a basket, and no local mischief resulted.

The authors sum up the results of their experiments under four heads: *A.* The "trophic" condition of the parts exposed. *B.* The state of general nutrition. *C.* Infection of the glands. *D.* Infection of the viscera.

A. "The local effects are nothing new. Many experimentors have observed the falling off of the hairs and the so-called burns caused by the X rays. These have generally been attributed to the electric field produced by the vacuum tube, and not to the X rays properly so called.

"In our experiments it was noticed that disturbances of the nutrition of the parts were produced only when the tube was placed so that nothing was interposed between it and the skin, and then only under certain conditions of energy and of distance. They were not present when either a thin board or the bottom of a wicker basket was interposed, even if the tube were placed very near.

"We made one interesting observation, viz., that the 'burning' was decidedly favoured by the presence of pre-existing lesions. It was not observed in subjects in which the tubercular affection was not commencing at the point of inoculation; indeed, we noticed that the ulcerations frequently began around fistulas or cicatrices situated at the point of inoculation, and we have seen them especially prevalent on the limb of that side.

"Moreover, having exposed guinea-pigs affected with small multiple abscesses at the site of subcutaneous injections of dead tubercle bacilli, we have noticed the abdominal walls, although submitted uniformly to the rays, show the 'burns,' especially at or around these abscesses, whether open or not."

B. The general nutrition was, in all the experiments, adversely influenced.

C. The treatment had a moderating influence on tubercular glands, causing a reduction in size of those already affected, and to some extent preventing their general infection.

D. The invasion of the viscera was rather favoured by the treatment.

"In no case was the animal benefited by the treatment."

Notices of Books.

TRAUMATIC SEPARATION OF THE EPIPHYSES. By JOHN POLAND, F.R.C.S. Surgeon to the Miller Hospital and to the City Orthopædic Hospital. London: Smith, Elder & Co.

This is a most excellent work, and is really a monument to the industry and knowledge of the author. It consists of upwards of 900 quarto pages, of large and easily readable type, and is profusely illustrated by no less than 880 excellent woodcuts.

It will be indispensable in a complete medical library, as a book of reference; but its price—two guineas net—will, we fear, be a bar to its purchase by every medical practitioner, and we venture to suggest that an abridged pocket edition would prove a success.

As the author says in his preface, "Whilst most standard works on surgery mention epiphysial separations, very few give any cases, or enter into details as to their diagnosis and treatment. They are continually mistaken for ordinary fractures or dislocations, and in many cases suitable treatment is not adopted."

It will be impossible, however, for such mistakes to happen when it becomes the routine practice, as must be the case in the near future, for every case of injury, *especially if it be near a joint, or if there be a suspicion of fracture or dislocation*, to be examined by the aid of the fluorescing screen or a radiograph.

The author, we are glad to see, shows his appreciation of this method of diagnosis, and it is because this is the first important surgical work, so far as we know, in which a serious attempt has been made to illustrate the subjects by radiograms that we notice it fully.

On page 97 he says: "The clinical application of the new skiagraphy by means of Roentgen rays is of great value in the diagnosis and elucidation of epiphysial lesions. The achieved and practical utility of this method of producing diagnostic photographs has been lately fully demonstrated by Mr. Sydney Rowland in the *Archives of Clinical Skiagraphy*, 1896" (now ARCHIVES OF THE ROENTGEN RAY); "and it is of very great importance to obtain skiagraphs of certain forms of recent complicated injuries to the epiphyses (*British Medical Journal*, March 7, 1896, p. 620). At the lower end of the humerus, for example, there are but few anatomical specimens in museums to guide the surgeon in making an exact diagnosis of the numerous and complicated lesions which, from daily experience, must exist during life. If this knowledge be obtained by Roentgen's method, it will materially assist the surgeon in giving a decision as to immediate operative measures in elbow-joint injuries of children, and in removing some of the many instances of subsequent severe deformity and loss of function of the joint and limb little creditable to surgery."

We may remark, however, that in addition to the value of this method for diagnostic purposes, it will be quite as useful after a broken limb is set; for the ends of an injured bone can be inspected by the aid of the fluorescing screen as often as may be necessary, without removing splints or dressing, and consequently without disturbing the parts or giving pain to the patient.

SPECIMEN ILLUSTRATION FROM POLAND'S "TRAUMATIC SEPARATION OF THE EPIPHYSES."

(*Reproduced by permission of Messrs. Smith, Elder and Co.*)

In the beginning of the book are a series of excellent radiograms, nineteen in number, of hands of young persons, aged

from one to seventeen years, illustrating the development of the epiphyses of the hand and wrist, by Mr. William Webster.

These, if we mistake not, are old friends, and were exhibited by Mr. Webster at the first conversazione of the Roentgen Society, in the autumn of 1897, as specimens of what could be done with short exposures, some of them being from snap-shots.

There is also a twentieth, by the same gentleman (at page 868), of the normal epiphyses of the ankle and foot of a child of 7 years.

There are, in addition, twenty-five radiograms illustrating injuries of various epiphyses taken by several radiographers. These are of different degrees of excellence as pictures, but most of them show the injury they are intended to depict very well, and the author claims that they have not been "touched up" in any way; and this is as it should be.

Dr. F. H. Low contributes two good clear representations of displacement of the epiphysis of the lower end of the humerus, and Professor Van Lennep, of Philadelphia, an excellent one of the same injury, taken through splints and bandages, and Dr. Charles L. Leonard, of the University Hospital of Pennsylvania, another.

Mr. Moore contributes eight radiograms—one of the same injury as the above, in which the fragments are widely separated, and were afterwards brought together by wiring, with a good result; another of fracture of the condyle of the humerus (the author's case), which is remarkable for having a number of black spots upon it which look somewhat as though they were due to "pin-holes" in the paper in which the sensitive plate was wrapped, but are in reality due to "calcareous nodules" in the subcutaneous tissue.

Mr. Charles Coppinger, of Dublin, sends "an early Roentgen picture," taken in May, 1896, of a displacement of the same epiphysis.

There is a remarkable case published by Professors White and Goodspeed, of the University of Pennsylvania, in the American *Journal of Medical Sciences*, August, 1896, of curvature of the bones of the fore-arm, produced by arrested development of the ulna at its distal epiphysis; and another, equally remarkable, of deformity and arrest of growth in the radius from an injury to the distal epiphysis, by Mr. William Thomas. A radiograph by Mr. Sydney Rowland shows well a separation of the distal end of the metacarpal bone of the fore-finger. There is a good radiograph showing fracture of the femur in a youth of twenty-one, taken by Messrs. Allen and Hanbury; and another by Dr. Royal Whitman, of New York, of a similar injury, in which the bones have been outlined.

A case of separation of the lower epiphysis of the humerus, with displacement downwards, is due to Mr. Stanley Kent, and there are five or six radiographs, the artists of which are not mentioned.

THE SKIAGRAPHIC ATLAS, by Mr. John Poland, F.R.C.S., is merely a reproduction of the radiographs by Mr. Webster, which are contained in the author's larger works. They are very well printed, and the book will doubtless be useful, as showing the development of the bones of the hand at different ages, especially as it contains some good explanatory notes.

Notes and Abstracts.

Dermatitis, etc.

Dr. Marc Ray Hughes, of St. Louis, U.S.A., announces that a thin sheet of indiarubber placed over the part during exposure to the X rays will prevent any bad effect on the skin. If it can be proved that this method gives perfect protection from any effects, such as dermatitis, etc., it will tend to show, what has often been suggested, that the effects are not due to the X rays, but to some other electrical effect, which the indiarubber, with its insulating properties, is able to keep off.

Depilation.

Messrs. Schiff and Freund find that seventeen to thirty short exposures to the X rays, lasting for about ten minutes each, will generally remove superfluous hair. In some cases the skin assumes a brown colour before depilation commences; in other cases, especially with brunettes, the hair becomes white before falling out. The tubes were placed at 20 to 25 cm. from the patient, care being taken that the strength of the rays and number of applications was such as to cause depilation without any other ill effects on the skin.

"*Fortschritte der Roentgenstrahlen*," *I.*, 244.

CONVERSAZIONE.

ON Monday, November 21, a most successful conversazione was given by the President, Mr. C. W. Mansell-Moullin, and Mrs. Mansell-Moullin, in St. Martin's Town Hall, Trafalgar Square. Over 1,400 guests were present, among whom were the following: Sir Jervais Glyn, Bart., and Lady Glyn; Sir William Boord, Bart.; Sir Thomas Smith, Bart.; Admiral the Right Hon. Sir J. Dalrymple Hay and Lady Hay; Sir Frederick and Lady Carden; Sir J. Kennaway, M.P.; Professor Silvanus P. Thompson, F.R.S.; Professor Gladstone, F.R.S.; Major Dodd, A.M.D.; Mr. Mackellar, F.R.C.S.; Mr. Stanley Boyd, F.R.C.S., and Mrs. Boyd; Professor

Hughes; Rev. C. T. and Mrs. Ackland; Dr. and Mrs. Ormerod; Dr. and Mrs. Sanson; Mr. Openshaw, F.R.C.S., and Mrs. Openshaw; Dr. and Mrs. Herman; Dr. and Mrs. Whitmore; Mr. and Mrs. Gordon Brown; Mr. and Mrs. Henry Bull; Rev. J. and Mrs. Cooke-Yarborough; Dr. and Mrs. Stringwell; Dr. and Mrs. Percy Kidd; Rev. Edgar and Mrs. Smith; Dr. and Mrs. Gilbart Smith; Mr. Wilson Noble; Mr. Mackenzie Davidson; Mr. A. A. Campbell Swinton; Mr. Thomas Moore, F.R.C.S., and Mrs. Moore; Mr. J. J. Vezey; Dr. and Mrs. W. S. Hedley; Mr. F. E. Fenton, F.R.C.S.; Dr. Norris Wolfenden; Dr. David Walsh; Mr. Sydney Rowland.

Tables were arranged round the large hall, and contained exhibits of Roentgen ray apparatus by members of the Society. Professor Gladstone, F.R.S., showed his apparatus for testing the grade of rays from a discharge tube, consisting of a small fluorescent screen fitted into a suitable fluoroscope, with a small "window" of platinum foil and a number of windows of aluminium foil of one or more layers; the latter were arranged round a disc so that each could be brought round into position beside the platinum window, and the relative fluorescence of the two compared. Dr. Hedley, assisted by Mr. E. Harnack, showed a complete outfit from the London Hospital; this included a dark tent for screen observation, the tube being placed on a stand outside, and a couch of transparent material on which the patient can recline, so that, if necessary, the tube can be placed below and the screen or plate above as the case may be. Dr. Hedley also showed a radio-stereoscope and a portable localizer. Mr. Herbert Jackson's original focus tube was shown by Mr. Webster, and special X ray tubes by Mr. A. A. Campbell Swinton, together with others of most ingenious construction for experiments with cathode rays. Mr. Cossor exhibited tubes with osmium anodes, and others for showing fluorescent phenomena, together with tube-stands, mercury-pumps, plate-holders, and McLeod's gauge. Mr. J. J. Vezey also had a collection of beautiful fluorescing tubes. Dr. Mackenzie Davidson showed two Wheatstone stereoscopes with radiographs mounted on four rotating drums, and also the latest pattern of his localizer.

Mr. Wimshurst, F.R.S., had an influence machine with twelve plates, 20 inches in diameter; and Dr. Lewis Jones one with four plates, 3 feet 6 inches in diameter. Mr. Apps exhibited an 18-inch coil; Mr. Watson Baker a Wyndt-Rochefort coil; Mr. Cox an 18-inch coil with new contact-breaker. A new portable X ray outfit was shown by Dr. Maw, and a simplified localizing apparatus and tube-stand by Mr. Coxeter. Mr. Isenthal exhibited a complete hospital outfit, including a coil and tube holder or stand, the movable part of which was held in position by an ingenious arrangement requiring only the adjustment of one screw; a new pattern of adjustable mercury-break was used in connection with the coil.

Mr. Fuerst brought some negatives taken with Lumière plates showing the sensitiveness of the special X plates to Roentgen rays. Mr. Conrad Cooke showed a special form of electroscope with high insulation, which would retain its charge for a long period. Tesla apparatus was exhibited by Mr. Leslie Miller, and also a Wireless Telegraphy apparatus which excited great interest.

Professor Silvanus P. Thompson showed experiments with the Tesla Oscillator under the gallery in the large hall. The two poles of the oscillator were connected with two large metal plates about 4 feet apart, so that the operator could stand between them and hold in his hands the various tubes, and observe the luminous phenomena produced in them by an electric field set up between the plates.

In the large screen-room, darkened for the purpose, were given demonstrations by Mr. Watson Baker, who brought a living rabbit in a leather bag, and a bird in a cage for examination with the rays, and also by Mr. Coldwell, Mr. Cox, Mr. Dean, Dr. Pepperdene, and Mr. Webster. In the smaller screen room special medical demonstrations were given by Dr. Walsh, Mr. Fenton, F.R.C.S., and Mr. Isenthal.

Radiographs were arranged on two large screens, one under the gallery, and another in the centre of the hall, under the superintendence of Mr. Snowden Ward. These were contributed by Messrs. Allen and Hanbury, Mr. Watson Baker, Dr. Barbour, Mr. Coldwell, Mr. Conrad Cooke, Mr. Coxeter, Mr. Hall Edwards, Mr. Fenton, Mr. J. H. Gardiner, Mr. Glew, Dr. Ernest Greville, Dr. Hedley, Dr. Boyd Keown, Dr. Low, Dr. E. L. Mansel, Mr. P. H. Marsden, Mr. Moore, Mr. Wilson Noble, Mr. E. Payne, Mr. John Poland, Mr. Noble Smith, Dr. Walsh, Dr. Hugh Walsham, Mr. Webster, Mr. Wilkin, and Dr. Wolfenden.

During the evening a selection of music was played by the London Concert Orchestra (Musical Director: Mr. Algernon Clarke). Mr. Fitzroy Sheridan contributed some excellent songs.

Description of Plates.

PLATE LI.

CENTRAL SARCOMA OF TIBIA.

This was taken from a patient in St. Bartholomew's Hospital suffering from central sarcoma of the tibia. It is an excellent radiograph, and shows plainly the disorganization of the bony structure in the central part of the growth, as the light seems to have gone through this part more even than through the muscular tissues. Around it, and more especially towards the fibula, is a portion of bone which is probably in the course of being invaded by the sarcomatous cells, as it is less dense than the surrounding bone structure, but not so translucent as the central portion.

PLATE LII.

CONGENITAL ABSENCE OF CLAVICLE.

An interesting case of congenital absence of the clavicles in a girl of fourteen, under the care of Dr. Schorstein in the London Hospital. On one side a small fragment of a clavicle may be seen, but on the other the bone appears to be entirely absent. The patient's shoulders can be brought together in front of the body.

Dr. Walsh showed a radiograph of a very smilar case at the last conversazione of the Roentgen Society.

PLATE LIII.

NEEDLE IN LUMBAR VERTEBRA.

Communicated by Mr. F. F. WARD, M.B. (Cantab), House Surgeon.

Mr. F. F. Ward writes that this case was admitted into the London Hospital, under the care of Mr. Mansell-Moullin, on July 15, 1898, with a history of having had half a darning-needle broken in the back three weeks previously.

" The radiograph showed it lying near the first and second lumbar vertebræ, but its outline was indistinct. Chloroform was administered, and, acting under the advice of Mr. Mansell-Moullin, as the needle could not be felt, I did not attempt to remove it. There was uncertainty as to whether the needle was dorsal or ventral to the vertebræ ; and, considering that it caused no irritation, it was thought unadvisable to attempt to remove it from such a position."

PLATE LIV. (*a*).

TUBERCULAR DISEASE OF ANKLE.

Mr. E. F. White, F.R.C.S., Putney, writes on November 6: "The patient was a boy, aged fourteen years. His illness dated from Christmas last. Pain on pressure over the external malleolus at first, followed in a month by swelling of the ankle-joint generally. The radiograph shows the bones of the tarsus to be almost transparent.

A diagnosis has been made of tubercular disease of the ankle, and the foot has been treated with rest and splints."

PLATE LIV. (*b*).

RHEUMATIC GOUT (?).

Notes by THOMAS JOYCE, M.D.

"The patient is a healthy-looking female aged sixty. The disease commenced when she was twenty-two years old as an acute attack of rheumatism in the dorsum of both hands, from which she recovered. After that the phalangeal joints began gradually to enlarge and flex, until they arrived at their present condition. It will be seen that in some of the joints, when the cartilage became sufficiently eroded, the superior power of the flexor muscles pulled the proximal ends of the next phalanx over, producing a complete dislocation forward. It will be noticed that the metacarpo-phalangeal joints are comparatively free from disease, so that flexion there is almost normal, and permits writing and painting to be efficiently performed. At the present time the left knee is becoming affected. The patient inherits a strong gouty tendency on the maternal side."

This may be compared with a hand by Mr. William Webster, published in the ARCHIVES OF THE ROENTGEN RAY for November, 1897, which was undoubtedly the hand of a gouty person. It will be seen that there is not the thickening of the radius, nor obliteration of the synovial membrane of the wrist-joint in the gouty case as in the other.

Are these two illustrations of distinct diseases, or of different stages of the same disease? A series of radiographs illustrating them would be of great interest, and might perhaps be collected by the Roentgen Society.

PLATE LV.

AMERICAN FROG.

Radiographed by Miss E. FLEISCHMAN, San Francisco.

The plate is a reproduction of one of several excellent radiographs sent to us by Miss E. Fleischman, of San Francisco, U.S.A. This, together with others including a fish and a kitten, was exhibited at the recent conversazione of the Roëntgen Society. They are interesting as specimens of work done with an influence machine.

PLATE LVI.

FRACTURED PATELLÆ.

These are taken from a woman admitted into the Miller Hospital eighteen months ago with a recent fracture of one patella. The radiograph shows well the tilting upwards of the broken end of the lower fragment, which is of common occurrence in these cases, and prevents the fractured ends from being brought together by bandages. This case was treated by wiring, with a good result.

The other patella had been fractured two years before and had been treated, "in another place," with splints and bandages. The patient was somewhat alcoholic and unamenable to discipline, hence probably the unfortunate result of the first breakage.

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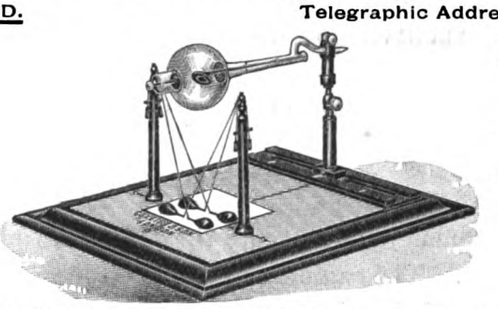

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"Of especial value it must be to those interested in legal medicine, who, in giving expert testimony on questions whose solutions rest upon individual observations, can find just here the needed information."—*Vienna Clinical Weekly Review.*

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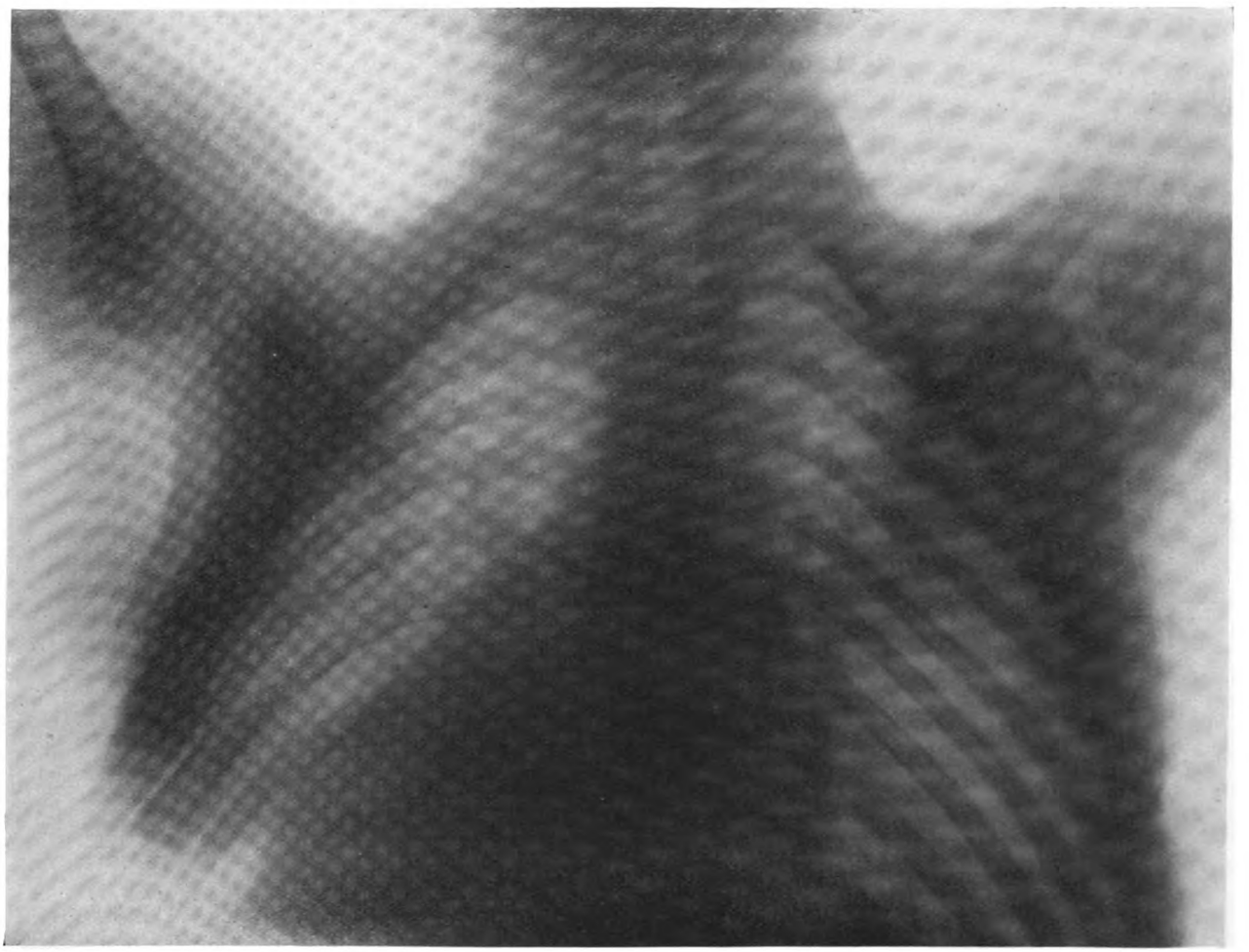
CENTRAL SARCOMA OF THE TIBIA.

Radiographed in the Electrical Department of St. Bartholomew's Hospital.
Principal: Dr. LEWIS JONES. Assistant: Dr. HUGH WALSHAM.

PLATE LI.

(*"Archives of the Roentgen Ray."—Copyright.*)



CONGENITAL ABSENCE OF THE CLAVICLES IN A GIRL OF FOURTEEN.

Dr. SCHORSTEIN'S Case.

Radiographed in the Electrical Department of the London Hospital.
Principal: Dr. W. S. HEDLEY. Assistant: Mr. E. H. HARNACK.

PLATE LII.

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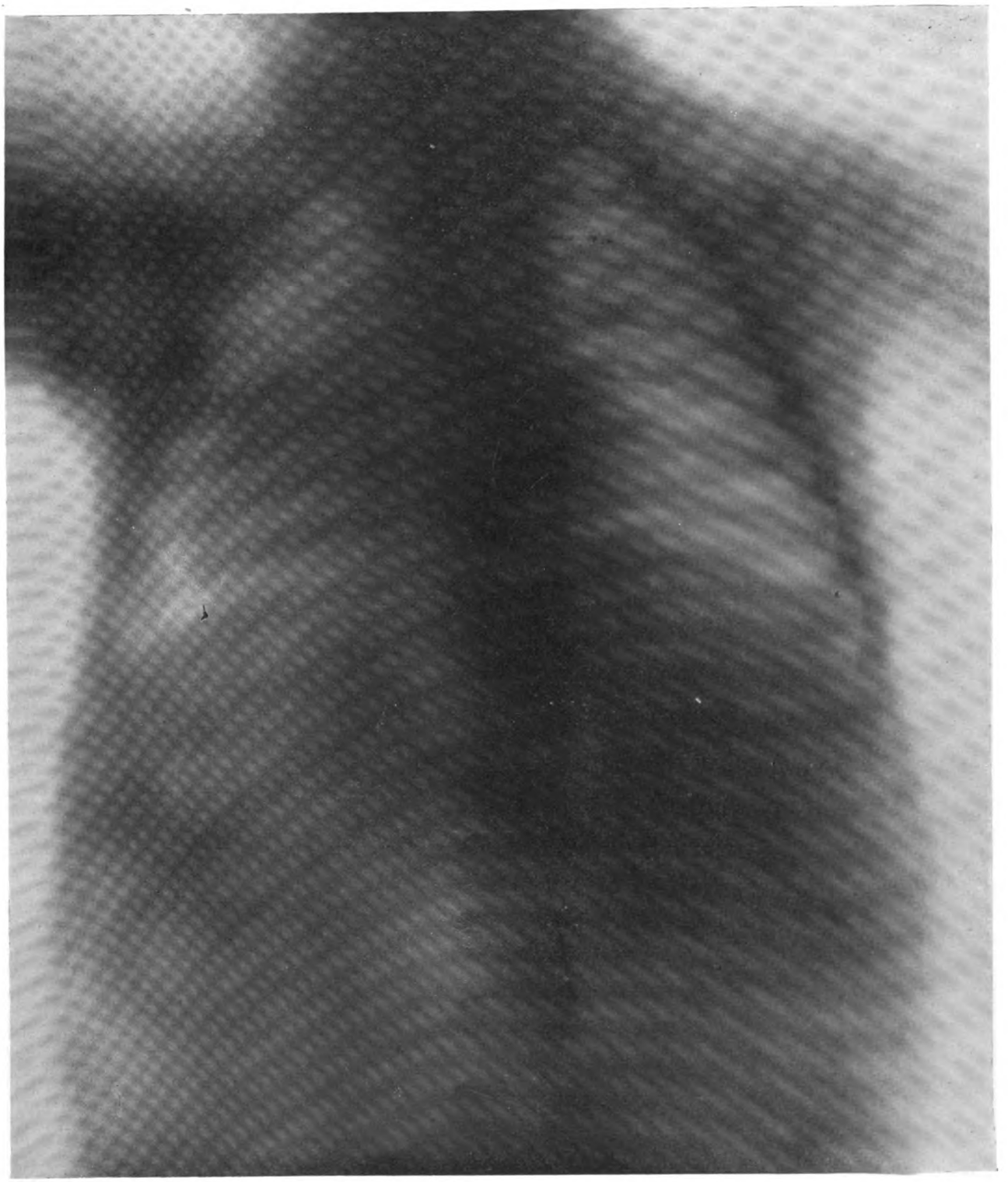

NEEDLE IN THE LUMBAR SPINE.

Mr. MANSELL-MOULLIN'S Case. Communicated by Mr. F. F. WARD, House Surgeon.

Radiographed in the Electrical Department of the London Hospital.
Principal: Dr. W. S. HEDLEY. Assistant: Mr. E. H. HARNACK.

PLATE LIII.

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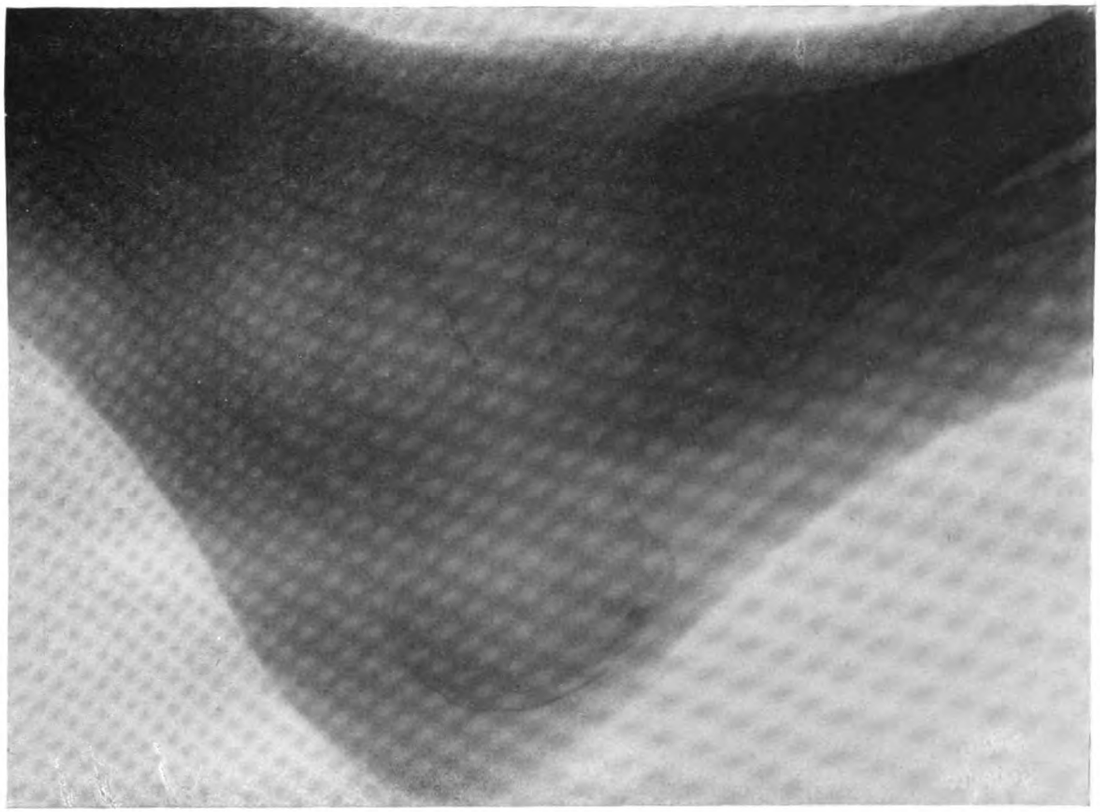

TUBERCULAR DISEASE OF THE TARSAL BONES.

Mr. WHITE'S Case. Radiographed by Mr. F. J. BUHL.

PLATE LIV. (*a*).

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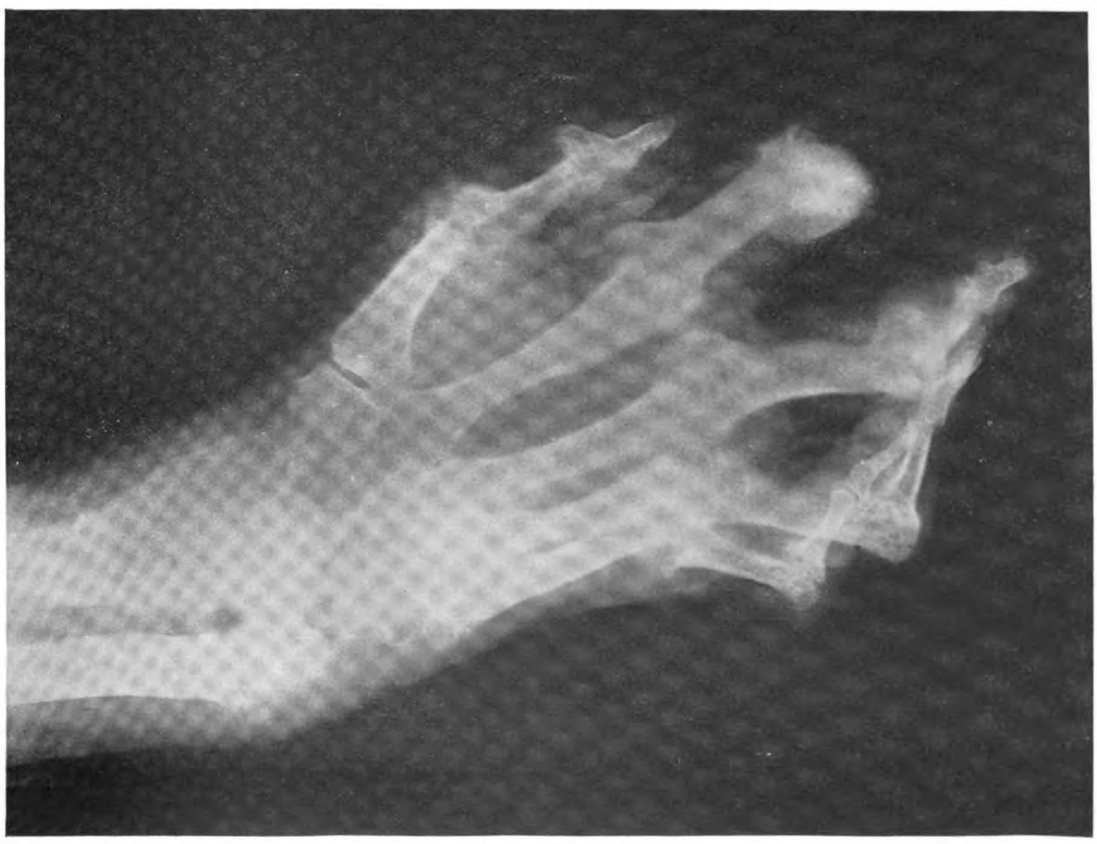


RHEUMATIC GOUT.

Dr. THOMAS JOYCE'S Case. Radiographed by Mr. WILSON NOBLE.

PLATE LIV. (*b*).

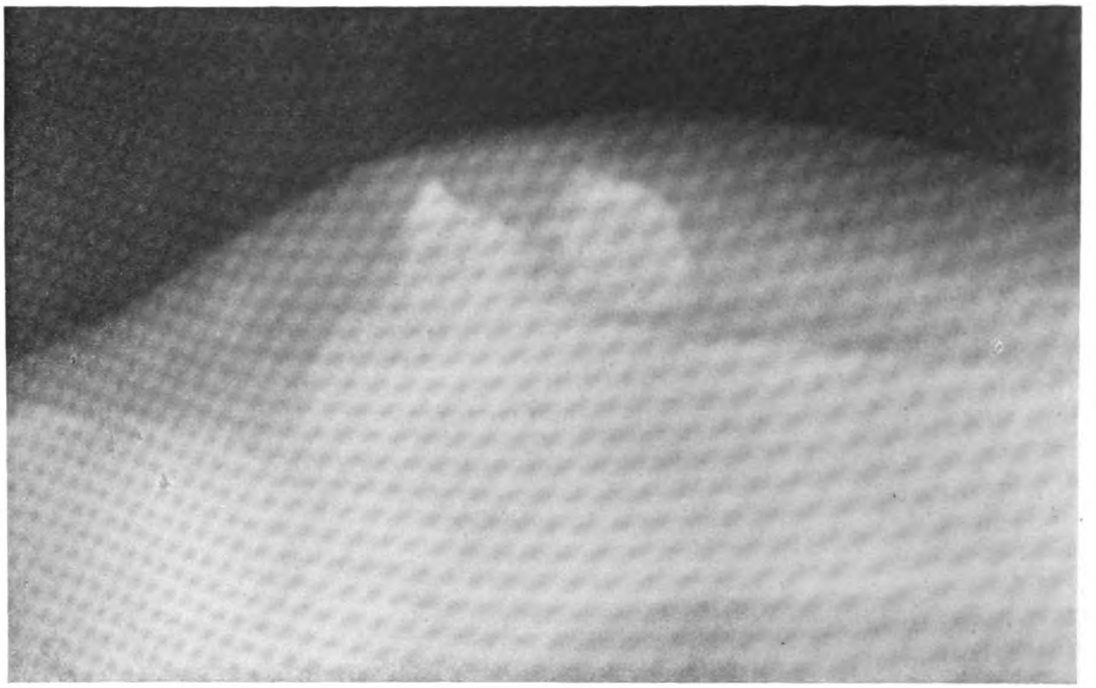
(*"Archives of the Roentgen Ray." -Copyright.*)

AN AMERICAN FROG.

Radiographed by Miss E. FLEISHMAN, San Francisco.

PLATE LV.

(*"Archives of the Roentgen Ray."—Copyright.*)



FRACTURE OF THE PATELLA (TWO DAYS AFTER INJURY).

Radiographed in the X ray department of the Miller Hospital, by Mr. THOMAS MOORE.

PLATE LVI. (*a*).

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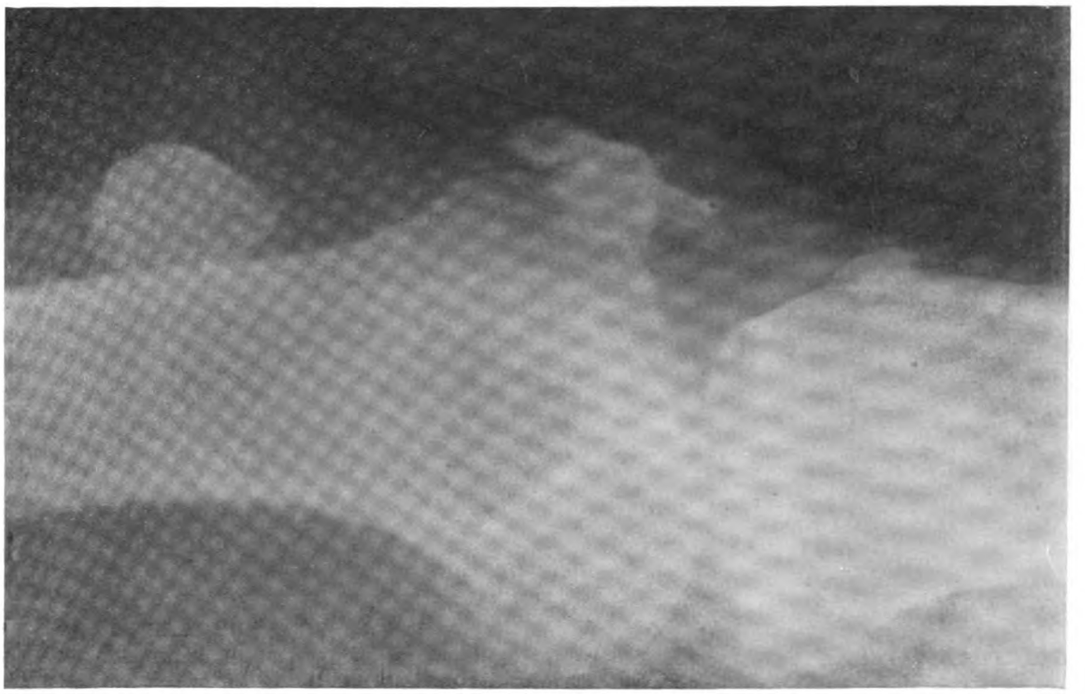

FRACTURE OF THE PATELLA (TWO YEARS AFTER INJURY),

IN THE SAME PATIENT AS THE ABOVE.

Radiographed in the X ray department of the Miller Hospital, by Mr. THOMAS MOORE.

PLATE LVI. (*b*).

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VOL. III.—No. 3.] FEBRUARY, 1899.

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— OF —

THE ROENTGEN RAY

(*Formerly* ARCHIVES OF SKIAGRAPHY).

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Surgeon to the Miller Hospital. | *A.I.E.E.*

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VOL. III.—No. 3.] FEBRUARY, 1899. [PRICE 4/- or $1.

ARCHIVES OF THE ROENTGEN RAY.

THE ROENTGEN SOCIETY.

A GENERAL MEETING of the Roentgen Society was held at 11, Chandos Street, Cavendish Square, on Tuesday, December 6, 1898, the President, Mr. W. C. Mansell-Moullin, M.D., F.R.C.S., in the chair.

The following were balloted for, and declared duly elected: A. H. Jones, M.D., M.R.C.P., Northampton, and T. Redmayne, M.A., M.B., F.R.C.S., St. Leonards.

Papers were read by Mr. E. PAYNE and Dr. WALSH on the subject of dermatitis following exposure to focus-tubes in action.

NOTES ON THE EFFECTS OF X RAYS.

By E. PAYNE, M.A.

THE following notes on the effects of X rays—injurious or otherwise—are not intended in any way to form an exhaustive treatise on the subject. They deal chiefly with some experiments and observations made in connection with the leakage discharge of current from the secondary wires and terminals of the tube and with the electrostatic charges on the surface of the tube. In the list of possible causes of dermatitis, etc., drawn up by the sub-committee these were the second and third.

The striking fact about these injurious effects after exposure to the X rays is perhaps their great rarity. The sub-committee appointed to collect information on the subject have as yet received reports of seven cases only, nearly all of which occurred in the early days—experimental days we might call them—of radiography. It is surprising that, if the X rays have the power of producing these injurious effects, they should not have occurred more often, especially when we consider the very large number of radiographs that were taken in early days, with long exposures, with a view to obtain pictures of the bones of the pelvis, lumbar vertebræ, renal calculi, tumours, etc. One is led to the conclusion that the condition and temperament of the patient must play an important part in the matter, whatever may be the real cause of the injury.

From our knowledge of the nature of X rays it is difficult to understand how the injuries can be produced, since there are neither heating nor decomposing effects. As we cannot prove by any single experiment that the injuries are due to the X rays alone, directly, the only method seems to be to carry out a number of careful experiments, excluding one by one all the other possible causes, from which we shall be forced to conclude that the effect must be due to the X rays. Even then the question arises whether there may not be rays emitted simultaneously with the X rays whose presence has not been detected hitherto, and which may be responsible for the effect, as suggested in the list issued by the sub-committee.

First, with regard to the leakage discharge from the terminals of the tube and secondary wires, I made the following experiment, with a somewhat unexpected result:

I placed on a table, below the tube, a sheet of tinfoil insulated by means of a glass plate, and connected it to one terminal of one of Lord Kelvin's electrostatic volt-meters, the other terminal being earthed. When the foil was 10 or 12 inches from the tube the direct charge communicated to the former was not sufficient to cause any deflection, as an E.M.F. of 50 volts was required to show one division on the scale. But when the tube was lowered, so that the terminal loop was 4 or 5 inches away, large deflections were obtained. I placed the foil first below one terminal of the tube and then below the other terminal. When the tinfoil was 4 inches from the terminal the reading was about 1,000 volts below the cathode end, but only about 500 below the anode end. Again, when the distance was 3 inches the reading showed about 1,650 volts when the foil was below the cathode terminal and about 1,200 volts when below the anode terminal.

The inequality of the two charges is the somewhat

unexpected result brought out by the experiment. The terminals and wire-connections of the tube were exactly similar at each end; it was about 10 inches long from one terminal to the other; an 18-inch coil was used, with a battery of 8 volts. We should conclude, therefore, that the negative charge imparted to any object brought near to the tube would be in excess of the positive charge, and thus there would not only be a small current passing through the object from the region below the anode to that below the cathode, but also a second current from earth to the part below the cathode. I have sometimes obtained small sparks from the head or shoulder of a patient while the tube was working, the head being below the cathode end, with the anode terminal towards the feet. Would this be accounted for by the current from earth just referred to?

In one of the cases reported some effect was produced on the skin on the under side of the body next to the plate. Now, if this was not due to the action of the rays, one would be disposed to suggest that it might have been due to this earth-current.

Next, with regard to the possible electrostatic effects of the charge on the surface of the tube and of the variations of the same, I endeavoured to make some observations with the aid of a gold-leaf electroscope, but with only partial success. When the electroscope was brought sufficiently near to the tube the leaves diverged, showing that there was a charge on the tube, but on shutting off the current the leaves fell together, as if the insulation of the electroscope were defective. This was not really so, as it retained a charge induced in the usual way from a stick of sealing-wax. It was not possible, therefore, to test accurately whether the charge in the electroscope was positive or negative. The constant movement of the leaves showed that the charge on the tube was continually varying, due to irregularities in the make and break in the primary circuit, and these changes would produce corresponding ones in the charge induced in any object near the tube. If the tube were running on an influence-machine these fluctuations would not be so great, and supposing that the effects on the skin were due to the continual variation of the static charge induced on it by the charge on the tube, this might account for the fact which has been asserted, that injurious effects are not so easily produced by a tube worked from a machine as by one running off an induction coil.

The difficulty of obtaining any charge on the electroscope suggests some action like that described by Lord Kelvin in his experiments on the discharge of electrified bodies in air under the influence of X rays.

Dr. M. R. Hughes, of St. Louis, U.S.A., has stated that a covering of sheet indiarubber will prevent any bad effects on the skin. I have not seen an account o any experiments made to prove this, but if it is a fac it would seem to show that the injurious effect must b due to some electric discharge (either alone or in com bination with other radiations), which is kept off by th insulating properties of the rubber.

Some definite experiments with a view to producin dermatitis for purposes of experiment have already bee made.

Dr. Lewis Jones describes an experiment made on h own hand, when he produced an X ray burn after total of five hours' exposure, the duration of exposu daily being about half an hour. No screens or oth covering were used. Dr. Jones agrees with the explan tion suggested by Dr. Edkins that "the interval betwe the exposure to the rays and the commencement visible effects therefrom pointed strongly to a conditi of trophic change following a nerve injury" (*Clini Journal*, March 30, 1898, p. 415).

Some careful experiments have been made by Profes Elihu Thomson, a summary of which is given in a pa in a recent number of the *American X ray Jour* (No. 5, November, 1898). Professor Thomson first p duced dermatitis on the little finger of his left hand exposing it, unprotected and unshielded, to the r He then made a second experiment on the next fin using a piece of sheet-lead with a window in it to li the effect. One half of this window was covered v aluminium foil, the other half being left open; der titis was produced both on the part that was un tected and also where it was screened by the alumin foil. From this he concludes that electrostatic e or electro-discharges were plainly ruled out. He produced a burn on another finger from a tube ru an influence machine, and expresses the opinion burns are produced by those rays of the X ray which are most readily absorbed by the flesh—viz., tubes of low vacuum.*

In the same journal there is an article by Dr. Leonard, of Philadelphia, on the subject of X ray matitis. He maintains that the devitalization destruction of tissue are due to the static charges, can be kept off by a metal screen, connected to

* See Abstract on p. 88.

and speaks of two cases where the rays were employed to produce a therapeutic effect, and where the omission of the screen allowed the static charge to produce a deep necrosis as the result of the devitalization of the tissues.* We have here two opposite opinions, both apparently verified by experiment.

Dr. Albers-Schönberg and Dr. Hahn, of Hamburg, who have recently treated cases of lupus and eczema very successfully with X rays, employ a cardboard mask covered with tinfoil, with holes to allow the rays to pass through where required, no effects being produced on the parts protected by the mask. This also tends to show that the effects are due to some form of radiation from the tube, and not in any way to the leakage-discharge.

In all cases where experiments are made with metal screens to keep off electrostatic effects it would appear necessary to connect them to earth by an independent wire, and not allow them to be in contact with the body. As there would be varying currents passing up and down the earth-wire with every change in the charge induced on the metal screen, so there would be similar currents through the skin and flesh near the points of contact with the screen if the body took the place of the earth-wire. In this case we should hardly feel sure that all electrostatic effects were ruled out.

When first I heard of X ray burns I adopted a covering of red silk; I chose the silk as being an insulating material most transparent to the rays. It was also suggested to me that the effect might possibly be due to some action similar to that of the sun, and having heard of a man in India who protected himself from sunstroke by having his clothes lined with red material, I adopted red as the colour of the silk. Whether the red colour has any effect on the radiations, whatever they may be, which produce dermatitis, I do not pretend to say, but I have never as yet had a case, although in early days I took a good many radiographs with long exposures of thirty to forty minutes each. If the silk has any preventive effect it is more likely to be due to the insulation than to anything in the colour.

In conclusion, I should like to mention very briefly the observations described by M. G. Sagnac in *Comptes Rendus* on secondary rays which are produced at the surface of impact and also of exit when the X rays pass through any substance. If these secondary rays play any part in the injurious effects, perhaps they would be responsible for the case above mentioned, where some injury was caused on the under side of the body next to the plate.

I have approached the subject with an open mind, ready to follow the evidence that appeared the most conclusive. The experiments carried out by Professor Elihu Thomson seem the most complete, as far as I have been able to obtain information, and one would feel disposed to conclude that the effects must be due to Roentgen or other rays coming from the tube, were it not for the definite cases given by Dr. C. L. Leonard, which seem to show that the static charge may also be capable of causing similar nerve injuries.

It seems that a few more experiments must be made before we can come to a definite conclusion.

We may, I think, safely assert that the length of exposure necessary to produce any injury is at least three or four times that required to obtain a radiograph with the improved apparatus now at our disposal, even where the most opaque parts of the body are concerned, and then only when the patient is specially susceptible to the electrical forces which cause the injury.

* See Abstract on p. 88.

FOCUS-TUBE DERMATITIS.

By DAVID WALSH, M.D.

Soon after the Roentgen rays came into general use, as everyone knows, cases of resulting injury to the skin began to be reported. This effect was usually spoken of as X ray dermatitis, but the present writer, in a paper* on the subject read before the Dermatological Society of Great Britain and Ireland, in July, 1897, ventured to suggest the use of the non-committal name of "focus-tube dermatitis." By either term is meant an inflammation of the skin following one or more exposures to a focus-tube in action. The damage may be fleeting; nothing more than a slight reddening of the skin, with sudden onset and rapid disappearance; or the hairs of the affected part may fall out painlessly. On the other hand, it may be severe, coming on from a few days to three weeks after the exposure; the epidermis may peel off (desquamation), or the underlying tissues may slough away and leave an obstinate ulcer that takes months to heal.

The existence of cause and effect in this condition has been established, both by the large number of recorded cases, and by certain experimental observations. Thus, Professor Elihu Thomson,† who was sceptical as to any

* *Transactions Dermatological Society Great Britain and Ireland*, vol. iii., p. 137.
† *Johns Hopkins Hospital Bulletin*, No. 71, February, 1897.

such injurious action, exposed his hand for half an hour at a few inches distance from a "live" tube, and was rewarded by the appearance of an eruption nine days later. Then, again, it is claimed that dermatitis may be set up at will by placing active tubes of medium resistance for ten or fifteen minutes at a short distance from the surface of the body. That the reaction may often exist in a minor degree and not be recognised seems likely. Only a week or two since, a Roentgen ray worker, in the course of a conversation, was hinting his doubts as to the occurrence of the condition, when I pointed it out to him on his own hands—that is to say, his fingers were red and leathery, and his nails brittle and broken, and wanting the sharp groove that defines the lower border of a healthy nail. Allowing, however, for cases that are not recognised, and for the far larger number that are not recorded, it nevertheless seems evident that the percentage of cases of dermatitis following exposure to the focus-tube must be extremely small. Of late, moreover, there has been a marked diminution of reported cases—a fact which appears to have some relation to the general shortening of exposures. Lastly, the affection seems to have attacked an undue proportion of practical workers who have been constantly exposed to the focus-tube rays, although the individual exposures may have been short.

There is nothing specific about the inflammation of the skin—nothing in its appearance that would proclaim it as due to the focus-tube. It is a symptom of a remote exciting cause, and exactly resembles the dermatitis set up by a number of other irritants, such as exposure to a hot sun, to a furnace, or to the action of a caustic alkali. The problem for us to solve is the nature of the irritant peculiar to the focus-tube.

If a multitude of persons be exposed to a hot sun, perhaps one out of a million will develop a severe dermatitis exactly resembling that set up by the focus-tube. In both cases there is a distinct, if imperfectly understood, *causa causans*, but something more is needed to account for the phenomenon of individual selection, and that we express by the convenient term "susceptibility." In this way the extremely small proportion of persons attacked by focus-tube dermatitis may be so far explained; many are exposed to the irritant, but few are susceptible.

Other contributing factors are seemingly the nearness of the focus-tube to the skin, the resistance of the tube, and the duration or frequency of the exposure. These assumptions—in addition to evidence that will be quoted forthwith—may be supported by the analogy of a han held near a hot furnace: the nearer the hand to the fi and the oftener or the longer it be placed there, th greater will be the resulting damage. The propositic that the injurious effects of the focus-tube are inverse proportional to the distance of tube from skin, and t length or frequency of exposure, is supported by t following evidence:

1. Close proximity of tube and an exposure of t or fifteen minutes is adopted to produce therapeutic intentional dermatitis.

2. In most of the recorded cases of injury, severe otherwise, the live tube has been placed near the skin a long time.

3. Repeated short exposures produce dermatitis those workers with the rays who are susceptible.

4. Professor Elihu Thomson's artificial dermatitis produced by a near tube and a long exposure.

5. Negatively, I cannot recall any recorded inst where a short exposure with the tube at a fair dist was followed by any seriously bad results.

These considerations appear well supported en to help clear the ground in various directions. T they show why cases of focus-tube dermatitis are so that their existence is denied by some persons; practical workers are specially prone to attack; and dermatitis has not occurred at all in the experien some extensive workers with the rays.

Fortunately, when we come to the considerati cases we have a number recorded by accurate obse So long ago as February, 1897, Mr. Gilchrist (*loc* was able to publish a collection of twenty-seven Without endeavouring to make an analysis of all rec instances, passing mention may be made of a fe have occurred in our own country, and that raise of special interest.

Dr. Radcliffe Crocker,* a good observer, in Ja 1897, published the case of a lad who developed and obstinate ulceration of the abdomen after a exposure of an hour's duration. The lower borde inflammatory area was sharply limited by the clo

In February, 1897, Professor Waymouth R highly-skilled and accurate observer, within fo underwent four exposures of twenty, forty, fif ninety minutes respectively, and afterwards from a severe dermatitis in the exposed area. P

* *British Medical Journal*, January 2, 1897.
† *Scottish Medical and Surgical Journal*, February, 1897.

Reid has further recorded the interesting fact that there was an erythema of the back, as well as of the chest; that is to say, presumably at the points both of entry and of exit of the irritant rays, unless, indeed, we attribute the result to direct or indirect electrical influences.

Speaking next of cases that have come within my own knowledge, I have noted* one in which congestion of a nail-bed followed the day after a four minutes' exposure of a hand with tube 12 inches from the plate.

I have also recorded† the case of one of our members, Mr. Webster, who had worked with the rays for more than a year without experiencing any bad results. He then began to heat the cathode end of the tube, and developed a typical dermatitis, which I had the opportunity of seeing. Something of the same kind happened in a second case, kindly communicated to me by Mr. Webster. The patient had been submitted to the rays about a score of times within a period of six months without ill effects therefrom, and it was only after the focus-tube was heated that he lost the hair on one side of his head.

A remarkable case has come to my knowledge within the last fortnight. A gentleman who had made something like two thousand Roentgen exposures, but had seen no ensuing ill effects, not unnaturally doubted the occurrence of dermatitis from that cause. At the recent conversazione of the Roentgen Society (November 21, 1898), he exposed his hand to a strange tube, and three days later developed a patch of dermatitis.

In my own case I have twice suffered from mild dermatitis of the left hand. On each occasion the attack followed a prolonged demonstration of the rays with the hand close to the focus-tube, and several sparks passed from the tube to the hand.

We have thus four cases in which individuals insusceptible to focus-tube injury under ordinary conditions became susceptible under altered conditions of experiment. In three at least the part affected was held close to a heated tube. It is generally believed that the effect of heating the cathodal end of the tube is to increase the production of cathode rays. Some of the latter appear to be convertible into heat upon striking the anti-cathode and the walls of the tube. I have elsewhere suggested‡ that it is not unthinkable that their impact upon the skin might have a similar calorific effect, which need not necessarily be exerted upon the outermost layer of the epidermis.

The analogy is not a little striking between focus-tube dermatitis and that produced in rare instances by exposure to a hot sun or to the heat of a furnace. Now, with regard to the exciting cause in all three conditions, we may observe:

1. That the dermatitis may arise from a single exposure.
2. That injury is excluded by clothing.
3. That chemical rays exist in each.
4. That deep as well as surface tissues may be affected.

1. That dermatitis may follow a single exposure to a hot sun* is an accepted medical fact; it is well known in the case of the focus-tube and obviously so with the furnace.

2. The second point is illustrated by the protection afforded against the effects of the sun by clothing, and in the case of the focus-tube by Dr. Crocker's case, in which the inflammation was sharply delimited by the clothing. Nor have I read or heard of any instance in which such an injury resulted in parts protected by clothes. Clearly, this observation alone, if established, would suffice to exclude the X rays pure and simple as the traumatic agency, for there is no ordinary clothing which they would not readily penetrate. An assumption of the innocence of the X rays has been implied in the attempts to prevent injury by interposing shields of indiarubber, vulcanite, and other materials that would not exclude X rays. One may remark, *obiter*, that the use of such preventive appliances involves a fallacy, inasmuch as the persons attacked under conditions of everyday work are so rare that the protective screen would have to be applied to an enormous number of exposures to enable one to arrive at any trustworthy general conclusion. If the gentleman already spoken of who made the two thousand exposures without bad results had used a vulcanite shield he might naturally have ascribed the absence of dermatitis to that precaution, and would thus have strayed into a logical pitfall. A more reasonable method would be to test the results of protected and unprotected exposures on different parts of persons of known susceptibility. It would be comparatively easy to devise a series of experiments which would definitely exclude all the less penetrating rays from the skin surface.

* "The Röntgen Rays in Medical Work," D. Walsh, M.D., pp. 111-120, 1897.
† *Ibid.* ‡ *Ibid.*

* See Jonathan Hutchinson's Smaller Clinical Atlas, Plate CX.

3. That chemical rays are emitted from sun, focus-tube, and furnace is a simple physical proposition, capable of easy proof.

4. With regard to the fourth point, Gilchrist (*loc. cit.*) described a case under Dr. Kolle where the dermatitis of a hand was accompanied by a deep inflammation of the underlying bones. I myself reported several cases of brain and abdominal symptoms in practical workers with the rays, presumably due to prolonged or repeated exposures. This deep tissue injury bears out still further the analogy between the ill effects of the rays of the sun and of the focus-tube. Another phenomenon sometimes produced by a Roentgen exposure is tremor of a limb, and has been noted by myself in one of two feet photographed on the same plate. Last summer I saw a patient suffering from sun dermatitis, the onset of which was marked with similar fine tremors. This observation appears to amplify the analogy.

From such considerations and facts as the foregoing I suggested a year ago that the focus-tube dermatitis might even prove to be due to heat rays; in other words, to a kind of burn. Perhaps the use of those terms was not altogether happy from a physicist standpoint, and the term "chemical rays" would have been more appropriate. My view was thus expressed: "On the whole, it seems not improbable that some common agent exists in the rays of the sun, of the focus-tube, and of the electric arc light capable of stimulating the human cutaneous surface, and sometimes the deeper tissues of the body, in varying degrees of severity, which are in some way determined by personal predisposing peculiarities."*

A curious confirmation of that hypothesis was advanced a few weeks since at the Austrian Gesellschaft der Aertze."† At that society Schiff showed a patient who had been treated with the focus-tube rays for lupus, and attributed the favourable result to the chemical action of the rays. He quoted Finsen, of Copenhagen, who recorded equal success with chemical rays not produced by Roentgen apparatus. His statement was confirmed by Spiegler, who said he had worked personally under Finsen with the treatment. The sun's rays were usually utilized for this purpose, and were passed through lenses to decompose the light before it was allowed to reach the morbid structures. At a later stage of the experimental treatment an electric arc light was used. Little glass plates were laid over the illumir ated surface to produce a sort of anæuria, or the actin ray would have checked the circulating blood altogethe

It may be stated generally that the view that tl injury is not due to the X rays pure and simple appea to gain favour in France, Germany, and America.

Various theories have been advanced to explain tl dermatitis. Of these the chief attribute the b results to:

1. Ozone-generation in skin.
2. Flights of platinum atoms.
3. Ultra-violet rays.
4. Radiant energy.
5. Rays of X ray order most readily absorbed.
6. Electrical induction.

1. Tesla's view that the damage is due to oz generated in the skin does not account for injury deep tissues.

2. There does not appear to be any general acc ance of the theory of the projection of streams of s particles through the walls of the tube.

3, 4, and 5 may be taken together. The term "rad energy" is wide and includes ultra-violet and absorb and chemical rays. Dr. Philip M. Jones of San F cisco, in a paper read before the California State Me Society, April 20, 1897, attributed the dermatitis tc absorption of radiant energy by the cells of the and thought it parallel with the changes effected ir photographic emulsion. Dr. Jones agrees with majority of observers that a bad result is more a follow exposure to a tube of low than of high vac The latter fact further tends to exonerate the X for, as Mr. Gardiner has shown at this Society, ' greatest production of X rays takes place in tul high resistance," which are the very tubes, accordi most authorities, the least likely to cause harm. U this same heading of radiant energy comes the c tion of Professor Elihu Thomson that "the burr produced chiefly by those rays of the X ray order are most readily absorbable by the flesh."†

6. The theory of electrical induction appears to l troverted by an experiment of Professor Elihu Thor In a sheet of lead he cut a window, which was c in two by a strip of tin foil, and one of the half-wi covered with a double layer of aluminium foil, th being bare. This shield was put on a finger, whi

* "The Röntgen Rays in Medical Work," D. Walsh, p. 116.
† *Medical Press and Circular*, November 23, 1898, p. 540.

* *Archives of the Roentgen Ray*, May, 1898, p. 70.
† *The American X-ray Journal*, November 12, 1898, p. 451.

exposed to a focus-tube. Two burns resulted: one on the part which had been under the aluminium foil, and the other on the bare spot. Professor Thomson thinks it inconceivable that any electrostatic effect could have acted more through the aluminium foil than through the tin foil or the sheet lead, as all three metals were in electrical contact and subjected to the same conditions.

A further argument against the induction theory may be found in the great amount of harmless electrification of skin often involved in therapeutic or experimental work. At the same time, it is likely we have yet to learn a good deal about the electrical states that are set up in the skin. In that structure we find externally a thin, hard, non-conducting layer of horny cells lying on the so-called "prickle" cells, which are bathed in serum, a fluid containing something like 5 per cent. of salt. The prickle cells lie in turn upon a close layer of cells known as the "palisade" layer, which is cut off by a thin membrane from the underlying tissues, charged with a hot alkaline fluid, the blood. All these layers are pierced by the hairs and the sweat ducts, both hair bulbs and sweat glands being in the deeper tissues. The brunt of the focus-tube damage in cases of moderate severity is borne by the palisade layer and by the hair-sheaths. As regards the hairs, one might almost imagine they had acted as conductors of some injurious electrical agency either to or from the body. At any rate, the reason why hairs alone should be selected for focus-tube attack in some instances is not apparent. The anatomical arrangement of the skin would on the face of it appear calculated to produce complicated electrostatic conditions. One noteworthy fact is that, under certain conditions, the sweat may become acid, and it is not impossible that some such fact would partly explain the little-understood problem of susceptibility.

Personally, I do not see why the dermatitis should not be due to various agencies acting either singly or together.

With regard to the use of the focus-tube as a depilatory and in the treatment of lupus a word of warning may be given. It is true that hairs may be thus destroyed. Destruction takes place in two ways: First, as the result of a mild selective inflammation, after which the hairs soon grow again; secondly, they may disappear permanently at the cost of deep and painful sloughing, and later of disfiguring scars. Much the same statements apply to lupus. In both cases the medical profession has appropriate remedies that are under perfect control. In our present state of knowledge it is not impossible that anyone who caused a disfigurement to a patient by the application of the focus-tube might lay himself open to an action for damages.

To sum up, then, I would say:

1. That a dermatitis, of varying severity, with a tendency to destroy hairs, deep layers of the epidermis and subcutaneous tissues, may be set up by exposure to a live focus-tube.

2. That the damage usually follows either a number of short exposures, or a single long exposure with tube close to the skin.

3. That while the injury, as a rule, affects susceptible persons, it may, nevertheless, be produced in insusceptible individuals under certain conditions.

4. That the inflammation is probably due in some way to chemical rays generated in the focus-tube, or to electrical conditions produced in the skin, or to a combination of those two agencies, and not to the X rays themselves.

[NOTE.—Dr. C. Thurston Holland's paper is referred to on page 80.

The PRESIDENT, after expressing the thanks of the meeting to the members who had contributed the foregoing papers, read extracts from a letter from Dr. Hall Edwards, of Birmingham, describing the treatment of two cases of lupus.

The President then drew attention to the fact that there appeared to be a marked difference between the effects produced by light and by the focus-tube. Those due to light appeared at once, while those due to the action of the tube did not appear until after an interval of time, varying in different cases. The injury following the exposure to the tube seemed to be due to some influence on the nerves, the slowness of cure showing evidence of neuritis, the effect being evidently deeper than the skin.

Mr. WEBSTER said he thought that the brush discharged from the terminals of the coil would produce the same effects as those attributed to the X rays. He accidentally received a shock through his foot and the nail of one of his toes came off, and the nail of his thumb and one finger came off from a similar cause. A gentleman, whose skull he had radiographed as an experiment, lost all the hair from the side of the head next the tube, but it soon grew again thicker than before. Professor Hodgkinson, of Woolwich, had suggested to him that the effect might be due to oxide of nitrogen produced on the skin. He also found that his hand was affected by the

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ARCHIVES

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(*Formerly* ARCHIVES OF SKIAGRAPHY).

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ARCHIVES OF THE ROENTGEN RAY.

THE ROENTGEN SOCIETY.

A GENERAL MEETING of the Roentgen Society was held at 11, Chandos Street, Cavendish Square, on Tuesday, December 6, 1898, the President, Mr. W. C. Mansell-Moullin, M.D., F.R.C.S., in the chair.

The following were balloted for, and declared duly elected: A. H. Jones, M.D., M.R.C.P., Northampton, and T. Redmayne, M.A., M.B., F.R.C.S., St. Leonards.

Papers were read by Mr. E. PAYNE and Dr. WALSH on the subject of dermatitis following exposure to focus-tubes in action.

NOTES ON THE EFFECTS OF X RAYS.

By E. PAYNE, M.A.

THE following notes on the effects of X rays—injurious or otherwise—are not intended in any way to form an exhaustive treatise on the subject. They deal chiefly with some experiments and observations made in connection with the leakage discharge of current from the secondary wires and terminals of the tube and with the electrostatic charges on the surface of the tube. In the list of possible causes of dermatitis, etc., drawn up by the sub-committee these were the second and third.

The striking fact about these injurious effects after exposure to the X rays is perhaps their great rarity. The sub-committee appointed to collect information on the subject have as yet received reports of seven cases only, nearly all of which occurred in the early days—experimental days we might call them—of radiography. It is surprising that, if the X rays have the power of producing these injurious effects, they should not have occurred more often, especially when we consider the very large number of radiographs that were taken in early days, with long exposures, with a view to obtain pictures of the bones of the pelvis, lumbar vertebræ, renal calculi, tumours, etc. One is led to the conclusion that the condition and temperament of the patient must play an important part in the matter, whatever may be the real cause of the injury.

From our knowledge of the nature of X rays it is difficult to understand how the injuries can be produced, since there are neither heating nor decomposing effects. As we cannot prove by any single experiment that the injuries are due to the X rays alone, directly, the only method seems to be to carry out a number of careful experiments, excluding one by one all the other possible causes, from which we shall be forced to conclude that the effect must be due to the X rays. Even then the question arises whether there may not be rays emitted simultaneously with the X rays whose presence has not been detected hitherto, and which may be responsible for the effect, as suggested in the list issued by the sub-committee.

First, with regard to the leakage discharge from the terminals of the tube and secondary wires, I made the following experiment, with a somewhat unexpected result:

I placed on a table, below the tube, a sheet of tinfoil insulated by means of a glass plate, and connected it to one terminal of one of Lord Kelvin's electrostatic volt-meters, the other terminal being earthed. When the foil was 10 or 12 inches from the tube the direct charge communicated to the former was not sufficient to cause any deflection, as an E.M.F. of 50 volts was required to show one division on the scale. But when the tube was lowered, so that the terminal loop was 4 or 5 inches away, large deflections were obtained. I placed the foil first below one terminal of the tube and then below the other terminal. When the tinfoil was 4 inches from the terminal the reading was about 1,000 volts below the cathode end, but only about 500 below the anode end. Again, when the distance was 3 inches the reading showed about 1,650 volts when the foil was below the cathode terminal and about 1,200 volts when below the anode terminal.

The inequality of the two charges is the somewhat

unexpected result brought out by the experiment. The terminals and wire-connections of the tube were exactly similar at each end; it was about 10 inches long from one terminal to the other; an 18-inch coil was used, with a battery of 8 volts. We should conclude, therefore, that the negative charge imparted to any object brought near to the tube would be in excess of the positive charge, and thus there would not only be a small current passing through the object from the region below the anode to that below the cathode, but also a second current from earth to the part below the cathode. I have sometimes obtained small sparks from the head or shoulder of a patient while the tube was working, the head being below the cathode end, with the anode terminal towards the feet. Would this be accounted for by the current from earth just referred to?

In one of the cases reported some effect was produced on the skin on the under side of the body next to the plate. Now, if this was not due to the action of the rays, one would be disposed to suggest that it might have been due to this earth-current.

Next, with regard to the possible electrostatic effects of the charge on the surface of the tube and of the variations of the same, I endeavoured to make some observations with the aid of a gold-leaf electroscope, but with only partial success. When the electroscope was brought sufficiently near to the tube the leaves diverged, showing that there was a charge on the tube, but on shutting off the current the leaves fell together, as if the insulation of the electroscope were defective. This was not really so, as it retained a charge induced in the usual way from a stick of sealing-wax. It was not possible, therefore, to test accurately whether the charge in the electroscope was positive or negative. The constant movement of the leaves showed that the charge on the tube was continually varying, due to irregularities in the make and break in the primary circuit, and these changes would produce corresponding ones in the charge induced in any object near the tube. If the tube were running on an influence-machine these fluctuations would not be so great, and supposing that the effects on the skin were due to the continual variation of the static charge induced on it by the charge on the tube, this might account for the fact which has been asserted, that injurious effects are not so easily produced by a tube worked from a machine as by one running off an induction coil.

The difficulty of obtaining any charge on the electroscope suggests some action like that described by Lord Kelvin in his experiments on the discharge of electrified bodies in air under the influence of X rays.

Dr. M. R. Hughes, of St. Louis, U.S.A., has stated that a covering of sheet indiarubber will prevent any bad effects on the skin. I have not seen an account of any experiments made to prove this, but if it is a fact it would seem to show that the injurious effect must be due to some electric discharge (either alone or in combination with other radiations), which is kept off by the insulating properties of the rubber.

Some definite experiments with a view to producing dermatitis for purposes of experiment have already been made.

Dr. Lewis Jones describes an experiment made on his own hand, when he produced an X ray burn after a total of five hours' exposure, the duration of exposure daily being about half an hour. No screens or other covering were used. Dr. Jones agrees with the explanation suggested by Dr. Edkins that "the interval between the exposure to the rays and the commencement of visible effects therefrom pointed strongly to a condition of trophic change following a nerve injury" (*Clinical Journal*, March 30, 1898, p. 415).

Some careful experiments have been made by Professor Elihu Thomson, a summary of which is given in a paper in a recent number of the *American X ray Journal* (No. 5, November, 1898). Professor Thomson first produced dermatitis on the little finger of his left hand by exposing it, unprotected and unshielded, to the rays. He then made a second experiment on the next finger, using a piece of sheet-lead with a window in it to limit the effect. One half of this window was covered with aluminium foil, the other half being left open; dermatitis was produced both on the part that was unprotected and also where it was screened by the aluminium foil. From this he concludes that electrostatic effect or electro-discharges were plainly ruled out. He also produced a burn on another finger from a tube run off an influence machine, and expresses the opinion that burns are produced by those rays of the X ray order which are most readily absorbed by the flesh—viz., from tubes of low vacuum.*

In the same journal there is an article by Dr. C. L. Leonard, of Philadelphia, on the subject of X ray dermatitis. He maintains that the devitalization and destruction of tissue are due to the static charges, which can be kept off by a metal screen, connected to earth,

* See Abstract on p. 88.

and speaks of two cases where the rays were employed to produce a therapeutic effect, and where the omission of the screen allowed the static charge to produce a deep necrosis as the result of the devitalization of the tissues.* We have here two opposite opinions, both apparently verified by experiment.

Dr. Albers-Schönberg and Dr. Hahn, of Hamburg, who have recently treated cases of lupus and eczema very successfully with X rays, employ a cardboard mask covered with tinfoil, with holes to allow the rays to pass through where required, no effects being produced on the parts protected by the mask. This also tends to show that the effects are due to some form of radiation from the tube, and not in any way to the leakage-discharge.

In all cases where experiments are made with metal screens to keep off electrostatic effects it would appear necessary to connect them to earth by an independent wire, and not allow them to be in contact with the body. As there would be varying currents passing up and down the earth-wire with every change in the charge induced on the metal screen, so there would be similar currents through the skin and flesh near the points of contact with the screen if the body took the place of the earth-wire. In this case we should hardly feel sure that all electrostatic effects were ruled out.

When first I heard of X ray burns I adopted a covering of red silk; I chose the silk as being an insulating material most transparent to the rays. It was also suggested to me that the effect might possibly be due to some action similar to that of the sun, and having heard of a man in India who protected himself from sunstroke by having his clothes lined with red material, I adopted red as the colour of the silk. Whether the red colour has any effect on the radiations, whatever they may be, which produce dermatitis, I do not pretend to say, but I have never as yet had a case, although in early days I took a good many radiographs with long exposures of thirty to forty minutes each. If the silk has any preventive effect it is more likely to be due to the insulation than to anything in the colour.

In conclusion, I should like to mention very briefly the observations described by M. G. Sagnac in *Comptes Rendus* on secondary rays which are produced at the surface of impact and also of exit when the X rays pass through any substance. If these secondary rays play any part in the injurious effects, perhaps they would be responsible for the case above mentioned, where some injury was caused on the under side of the body next to the plate.

I have approached the subject with an open mind, ready to follow the evidence that appeared the most conclusive. The experiments carried out by Professor Elihu Thomson seem the most complete, as far as I have been able to obtain information, and one would feel disposed to conclude that the effects must be due to Roentgen or other rays coming from the tube, were it not for the definite cases given by Dr. C. L. Leonard, which seem to show that the static charge may also be capable of causing similar nerve injuries.

It seems that a few more experiments must be made before we can come to a definite conclusion.

We may, I think, safely assert that the length of exposure necessary to produce any injury is at least three or four times that required to obtain a radiograph with the improved apparatus now at our disposal, even where the most opaque parts of the body are concerned, and then only when the patient is specially susceptible to the electrical forces which cause the injury.

* See Abstract on p. 88.

FOCUS-TUBE DERMATITIS.

By DAVID WALSH, M.D.

Soon after the Roentgen rays came into general use, as everyone knows, cases of resulting injury to the skin began to be reported. This effect was usually spoken of as X ray dermatitis, but the present writer, in a paper* on the subject read before the Dermatological Society of Great Britain and Ireland, in July, 1897, ventured to suggest the use of the non-committal name of "focus-tube dermatitis." By either term is meant an inflammation of the skin following one or more exposures to a focus-tube in action. The damage may be fleeting; nothing more than a slight reddening of the skin, with sudden onset and rapid disappearance; or the hairs of the affected part may fall out painlessly. On the other hand, it may be severe, coming on from a few days to three weeks after the exposure; the epidermis may peel off (desquamation), or the underlying tissues may slough away and leave an obstinate ulcer that takes months to heal.

The existence of cause and effect in this condition has been established, both by the large number of recorded cases, and by certain experimental observations. Thus, Professor Elihu Thomson,† who was sceptical as to any

* *Transactions Dermatological Society Great Britain and Ireland*, vol. iii., p. 137.
† *Johns Hopkins Hospital Bulletin*, No. 71, February, 1897.

such injurious action, exposed his hand for half an hour at a few inches distance from a "live" tube, and was rewarded by the appearance of an eruption nine days later. Then, again, it is claimed that dermatitis may be set up at will by placing active tubes of medium resistance for ten or fifteen minutes at a short distance from the surface of the body. That the reaction may often exist in a minor degree and not be recognised seems likely. Only a week or two since, a Roentgen ray worker, in the course of a conversation, was hinting his doubts as to the occurrence of the condition, when I pointed it out to him on his own hands—that is to say, his fingers were red and leathery, and his nails brittle and broken, and wanting the sharp groove that defines the lower border of a healthy nail. Allowing, however, for cases that are not recognised, and for the far larger number that are not recorded, it nevertheless seems evident that the percentage of cases of dermatitis following exposure to the focus-tube must be extremely small. Of late, moreover, there has been a marked diminution of reported cases—a fact which appears to have some relation to the general shortening of exposures. Lastly, the affection seems to have attacked an undue proportion of practical workers who have been constantly exposed to the focus-tube rays, although the individual exposures may have been short.

There is nothing specific about the inflammation of the skin—nothing in its appearance that would proclaim it as due to the focus-tube. It is a symptom of a remote exciting cause, and exactly resembles the dermatitis set up by a number of other irritants, such as exposure to a hot sun, to a furnace, or to the action of a caustic alkali. The problem for us to solve is the nature of the irritant peculiar to the focus-tube.

If a multitude of persons be exposed to a hot sun, perhaps one out of a million will develop a severe dermatitis exactly resembling that set up by the focus-tube. In both cases there is a distinct, if imperfectly understood, *causa causans*, but something more is needed to account for the phenomenon of individual selection, and that we express by the convenient term "susceptibility." In this way the extremely small proportion of persons attacked by focus-tube dermatitis may be so far explained; many are exposed to the irritant, but few are susceptible.

Other contributing factors are seemingly the nearness of the focus-tube to the skin, the resistance of the tube, and the duration or frequency of the exposure. These assumptions—in addition to evidence that will be quoted forthwith—may be supported by the analogy of a hand held near a hot furnace: the nearer the hand to the fire and the oftener or the longer it be placed there, the greater will be the resulting damage. The proposition that the injurious effects of the focus-tube are inversely proportional to the distance of tube from skin, and the length or frequency of exposure, is supported by the following evidence:

1. Close proximity of tube and an exposure of ten or fifteen minutes is adopted to produce therapeutic or intentional dermatitis.

2. In most of the recorded cases of injury, severe or otherwise, the live tube has been placed near the skin for a long time.

3. Repeated short exposures produce dermatitis in those workers with the rays who are susceptible.

4. Professor Elihu Thomson's artificial dermatitis was produced by a near tube and a long exposure.

5. Negatively, I cannot recall any recorded instance where a short exposure with the tube at a fair distance was followed by any seriously bad results.

These considerations appear well supported enough to help clear the ground in various directions. Thus, they show why cases of focus-tube dermatitis are so rare that their existence is denied by some persons; why practical workers are specially prone to attack; and why dermatitis has not occurred at all in the experience of some extensive workers with the rays.

Fortunately, when we come to the consideration of cases we have a number recorded by accurate observers. So long ago as February, 1897, Mr. Gilchrist (*loc. cit.*) was able to publish a collection of twenty-seven cases. Without endeavouring to make an analysis of all recorded instances, passing mention may be made of a few that have occurred in our own country, and that raise points of special interest.

Dr. Radcliffe Crocker,* a good observer, in January, 1897, published the case of a lad who developed a large and obstinate ulceration of the abdomen after a single exposure of an hour's duration. The lower border of the inflammatory area was sharply limited by the clothing.

In February, 1897, Professor Waymouth Reid,† a highly-skilled and accurate observer, within four days underwent four exposures of twenty, forty, fifty, and ninety minutes respectively, and afterwards suffered from a severe dermatitis in the exposed area. Professor

* *British Medical Journal*, January 2, 1897.
† *Scottish Medical and Surgical Journal*, February, 1897.

Reid has further recorded the interesting fact that there was an erythema of the back, as well as of the chest; that is to say, presumably at the points both of entry and of exit of the irritant rays, unless, indeed, we attribute the result to direct or indirect electrical influences.

Speaking next of cases that have come within my own knowledge, I have noted* one in which congestion of a nail-bed followed the day after a four minutes' exposure of a hand with tube 12 inches from the plate.

I have also recorded† the case of one of our members, Mr. Webster, who had worked with the rays for more than a year without experiencing any bad results. He then began to heat the cathode end of the tube, and developed a typical dermatitis, which I had the opportunity of seeing. Something of the same kind happened in a second case, kindly communicated to me by Mr. Webster. The patient had been submitted to the rays about a score of times within a period of six months without ill effects therefrom, and it was only after the focus-tube was heated that he lost the hair on one side of his head.

A remarkable case has come to my knowledge within the last fortnight. A gentleman who had made something like two thousand Roentgen exposures, but had seen no ensuing ill effects, not unnaturally doubted the occurrence of dermatitis from that cause. At the recent conversazione of the Roentgen Society (November 21, 1898), he exposed his hand to a strange tube, and three days later developed a patch of dermatitis.

In my own case I have twice suffered from mild dermatitis of the left hand. On each occasion the attack followed a prolonged demonstration of the rays with the hand close to the focus-tube, and several sparks passed from the tube to the hand.

We have thus four cases in which individuals insusceptible to focus-tube injury under ordinary conditions became susceptible under altered conditions of experiment. In three at least the part affected was held close to a heated tube. It is generally believed that the effect of heating the cathodal end of the tube is to increase the production of cathode rays. Some of the latter appear to be convertible into heat upon striking the anti-cathode and the walls of the tube. I have elsewhere suggested‡ that it is not unthinkable that their impact upon the skin might have a similar calorific effect, which need not necessarily be exerted upon the outermost layer of the epidermis.

The analogy is not a little striking between focus-tube dermatitis and that produced in rare instances by exposure to a hot sun or to the heat of a furnace. Now, with regard to the exciting cause in all three conditions, we may observe:

1. That the dermatitis may arise from a single exposure.
2. That injury is excluded by clothing.
3. That chemical rays exist in each.
4. That deep as well as surface tissues may be affected.

1. That dermatitis may follow a single exposure to a hot sun* is an accepted medical fact; it is well known in the case of the focus-tube and obviously so with the furnace.

2. The second point is illustrated by the protection afforded against the effects of the sun by clothing, and in the case of the focus-tube by Dr. Crocker's case, in which the inflammation was sharply delimited by the clothing. Nor have I read or heard of any instance in which such an injury resulted in parts protected by clothes. Clearly, this observation alone, if established, would suffice to exclude the X rays pure and simple as the traumatic agency, for there is no ordinary clothing which they would not readily penetrate. An assumption of the innocence of the X rays has been implied in the attempts to prevent injury by interposing shields of indiarubber, vulcanite, and other materials that would not exclude X rays. One may remark, *obiter*, that the use of such preventive appliances involves a fallacy, inasmuch as the persons attacked under conditions of everyday work are so rare that the protective screen would have to be applied to an enormous number of exposures to enable one to arrive at any trustworthy general conclusion. If the gentleman already spoken of who made the two thousand exposures without bad results had used a vulcanite shield he might naturally have ascribed the absence of dermatitis to that precaution, and would thus have strayed into a logical pitfall. A more reasonable method would be to test the results of protected and unprotected exposures on different parts of persons of known susceptibility. It would be comparatively easy to devise a series of experiments which would definitely exclude all the less penetrating rays from the skin surface.

* "The Röntgen Rays in Medical Work," D. Walsh, M.D., pp. 111-120, 1897.
† *Ibid.* ‡ *Ibid.*

* See Jonathan Hutchinson's Smaller Clinical Atlas, Plate CX.

3. That chemical rays are emitted from sun, focus-tube, and furnace is a simple physical proposition, capable of easy proof.

4. With regard to the fourth point, Gilchrist (*loc. cit.*) described a case under Dr. Kolle where the dermatitis of a hand was accompanied by a deep inflammation of the underlying bones. I myself reported several cases of brain and abdominal symptoms in practical workers with the rays, presumably due to prolonged or repeated exposures. This deep tissue injury bears out still further the analogy between the ill effects of the rays of the sun and of the focus-tube. Another phenomenon sometimes produced by a Roentgen exposure is tremor of a limb, and has been noted by myself in one of two feet photographed on the same plate. Last summer I saw a patient suffering from sun dermatitis, the onset of which was marked with similar fine tremors. This observation appears to amplify the analogy.

From such considerations and facts as the foregoing I suggested a year ago that the focus-tube dermatitis might even prove to be due to heat rays; in other words, to a kind of burn. Perhaps the use of those terms was not altogether happy from a physicist standpoint, and the term "chemical rays" would have been more appropriate. My view was thus expressed: "On the whole, it seems not improbable that some common agent exists in the rays of the sun, of the focus-tube, and of the electric arc light capable of stimulating the human cutaneous surface, and sometimes the deeper tissues of the body, in varying degrees of severity, which are in some way determined by personal predisposing peculiarities."*

A curious confirmation of that hypothesis was advanced a few weeks since at the Austrian Gesellschaft der Aertze."† At that society Schiff showed a patient who had been treated with the focus-tube rays for lupus, and attributed the favourable result to the chemical action of the rays. He quoted Finsen, of Copenhagen, who recorded equal success with chemical rays not produced by Roentgen apparatus. His statement was confirmed by Spiegler, who said he had worked personally under Finsen with the treatment. The sun's rays were usually utilized for this purpose, and were passed through lenses to decompose the light before it was allowed to reach the morbid structures. At a later stage of the experimental treatment an electric arc light was used. Little glass plates were laid over the illuminated surface to produce a sort of anæuria, or the acting ray would have checked the circulating blood altogether.

It may be stated generally that the view that the injury is not due to the X rays pure and simple appears to gain favour in France, Germany, and America.

Various theories have been advanced to explain the dermatitis. Of these the chief attribute the bad results to:

1. Ozone-generation in skin.
2. Flights of platinum atoms.
3. Ultra-violet rays.
4. Radiant energy.
5. Rays of X ray order most readily absorbed.
6. Electrical induction.

1. Tesla's view that the damage is due to ozone generated in the skin does not account for injury to deep tissues.

2. There does not appear to be any general acceptance of the theory of the projection of streams of solid particles through the walls of the tube.

3, 4, and 5 may be taken together. The term "radiant energy" is wide and includes ultra-violet and absorbable and chemical rays. Dr. Philip M. Jones of San Francisco, in a paper read before the California State Medical Society, April 20, 1897, attributed the dermatitis to the absorption of radiant energy by the cells of the skin, and thought it parallel with the changes effected in the photographic emulsion. Dr. Jones agrees with the majority of observers that a bad result is more apt to follow exposure to a tube of low than of high vacuum. The latter fact further tends to exonerate the X rays, for, as Mr. Gardiner has shown at this Society, "The greatest production of X rays takes place in tubes of high resistance," which are the very tubes, according to most authorities, the least likely to cause harm. Under this same heading of radiant energy comes the contention of Professor Elihu Thomson that "the burns are produced chiefly by those rays of the X ray order which are most readily absorbable by the flesh."†

6. The theory of electrical induction appears to be controverted by an experiment of Professor Elihu Thomson's. In a sheet of lead he cut a window, which was divided in two by a strip of tin foil, and one of the half-windows covered with a double layer of aluminium foil, the other being bare. This shield was put on a finger, which was

* "The Röntgen Rays in Medical Work," D. Walsh, p. 116.
† *Medical Press and Circular*, November 23, 1898, p. 540.

* *Archives of the Roentgen Ray*, May, 1898, p. 70.
† *The American X-ray Journal*, November 12, 1898, p. 451.

exposed to a focus-tube. Two burns resulted: one on the part which had been under the aluminium foil, and the other on the bare spot. Professor Thomson thinks it inconceivable that any electrostatic effect could have acted more through the aluminium foil than through the tin foil or the sheet lead, as all three metals were in electrical contact and subjected to the same conditions.

A further argument against the induction theory may be found in the great amount of harmless electrification of skin often involved in therapeutic or experimental work. At the same time, it is likely we have yet to learn a good deal about the electrical states that are set up in the skin. In that structure we find externally a thin, hard, non-conducting layer of horny cells lying on the so-called "prickle" cells, which are bathed in serum, a fluid containing something like 5 per cent. of salt. The prickle cells lie in turn upon a close layer of cells known as the "palisade" layer, which is cut off by a thin membrane from the underlying tissues, charged with a hot alkaline fluid, the blood. All these layers are pierced by the hairs and the sweat ducts, both hair bulbs and sweat glands being in the deeper tissues. The brunt of the focus-tube damage in cases of moderate severity is borne by the palisade layer and by the hair-sheaths. As regards the hairs, one might almost imagine they had acted as conductors of some injurious electrical agency either to or from the body. At any rate, the reason why hairs alone should be selected for focus-tube attack in some instances is not apparent. The anatomical arrangement of the skin would on the face of it appear calculated to produce complicated electrostatic conditions. One noteworthy fact is that, under certain conditions, the sweat may become acid, and it is not impossible that some such fact would partly explain the little-understood problem of susceptibility.

Personally, I do not see why the dermatitis should not be due to various agencies acting either singly or together.

With regard to the use of the focus-tube as a depilatory and in the treatment of lupus a word of warning may be given. It is true that hairs may be thus destroyed. Destruction takes place in two ways: First, as the result of a mild selective inflammation, after which the hairs soon grow again; secondly, they may disappear permanently at the cost of deep and painful sloughing, and later of disfiguring scars. Much the same statements apply to lupus. In both cases the medical profession has appropriate remedies that are under perfect control. In our present state of knowledge it is not impossible that anyone who caused a disfigurement to a patient by the application of the focus-tube might lay himself open to an action for damages.

To sum up, then, I would say:

1. That a dermatitis, of varying severity, with a tendency to destroy hairs, deep layers of the epidermis and subcutaneous tissues, may be set up by exposure to a live focus-tube.

2. That the damage usually follows either a number of short exposures, or a single long exposure with tube close to the skin.

3. That while the injury, as a rule, affects susceptible persons, it may, nevertheless, be produced in insusceptible individuals under certain conditions.

4. That the inflammation is probably due in some way to chemical rays generated in the focus-tube, or to electrical conditions produced in the skin, or to a combination of those two agencies, and not to the X rays themselves.

[NOTE.—Dr. C. Thurston Holland's paper is referred to on page 80.

The PRESIDENT, after expressing the thanks of the meeting to the members who had contributed the foregoing papers, read extracts from a letter from Dr. Hall Edwards, of Birmingham, describing the treatment of two cases of lupus.

The President then drew attention to the fact that there appeared to be a marked difference between the effects produced by light and by the focus-tube. Those due to light appeared at once, while those due to the action of the tube did not appear until after an interval of time, varying in different cases. The injury following the exposure to the tube seemed to be due to some influence on the nerves, the slowness of cure showing evidence of neuritis, the effect being evidently deeper than the skin.

Mr. WEBSTER said he thought that the brush discharged from the terminals of the coil would produce the same effects as those attributed to the X rays. He accidentally received a shock through his foot and the nail of one of his toes came off, and the nail of his thumb and one finger came off from a similar cause. A gentleman, whose skull he had radiographed as an experiment, lost all the hair from the side of the head next the tube, but it soon grew again thicker than before. Professor Hodgkinson, of Woolwich, had suggested to him that the effect might be due to oxide of nitrogen produced on the skin. He also found that his hand was affected by the

rays while holding the spirit-lamp below the tube to heat it, and he had adopted a thin metal screen as a protection, composed of a sheet of ferrotype with a hole in it fitting over the lamp. He had also noticed that anæmic people complained of feeling cold on the part on which the rays fell, while gouty people said there was a sensation of warmth from the tube.

Mr. ISENTHAL thought that the effect could not be due to any electrolytic action produced by leakage of current from the wires. German experimenters had carefully insulated their patients, and found that the same effects could be produced.

Mr. GRIFFITH WILKIN described a case of injury to the shoulder resulting from a fall from a dogcart. The arm and shoulder were radiographed, a total exposure of about half an hour being required. About a fortnight after the radiographs were taken a black circle appeared over the pectoral muscles nearly as large as a dinner-plate. The colour changed gradually from black to brown; there was considerable irritation and the ribs were tender. After three weeks the skin assumed its normal appearance.

Mr. VEZEY said that if the red material would keep off the bad effects following exposure to a tube, it would appear to show that these effects were due to the actinic rays.

Mr. PHILLIPS suggested that a series of careful experiments might be carried out by the Society, or by a committee appointed for the purpose; and asked also whether any experiments had been made on animals.

Dr. GRIFFITH WILKIN referred to the feeling of numbness and tingling experienced by some patients as indicating that there was an effect on the nerves.

Mr. WILSON NOTH suggested that in some cases the feeling of tingling was due to the vibration of the hammer of the contact-breaker when the coil stood on the same table on which the patient's arm, etc., was placed for taking the radiograph. Before taking a radiograph of the head of a lady who was suffering from an injury to the jaw, he had experimented on his own head, placing it as near as possible to the tube, and found that the sensation produced was very similar to that of the sun. The case of the man in India who had used red material as a lining to his clothes, mentioned by Mr. Payne, was probably the one brought before the Camera Club a short time ago.

THE ROENTGEN SOCIETY.

A GENERAL MEETING of the Roentgen Society was held at 11, Chandos Street, Cavendish Square, London, on Tuesday, January 10, 1899, the President, Mr. C. W. Mansell-Moullin, M.D., F.R.C.S., in the chair.

The following were balloted for, and declared duly elected: T. J. Webster, M.R.C.S., Brynglas, Merthyr Tydvil; H. A. Kent, 59, Myddleton Road, Bowes Park, W.; G. E. Pritchett, Oak House, Bishop's Stortford; James Taylor, M.R.C.S., 36, Alma Road, Clifton, Bristol; A. Erd, M.D., Cairo, Egypt.

A paper was read by J. Battersby, M.B., Major, Royal Army Medical Corps, on "The Present Position of the Roentgen Rays in Military Surgery," illustrated with a series of interesting lantern-slides from photographs and radiographs taken in Egypt during the recent war in the Soudan.

THE PRESENT POSITION OF THE ROENTGEN RAYS IN MILITARY SURGERY.

By J. BATTERSBY, M.B., MAJOR R.A.M.C.

MR. PRESIDENT AND GENTLEMEN,

In the first place, I desire to thank you for your kindness in inviting me here to-night, and also to acknowledge the great honour your Society has conferred upon me by asking me to read this paper before an audience so eminently critical.

Before proceeding to the subject of my address, I wish to take this opportunity of expressing my gratitude to Mr. Mackenzie Davidson for the great assistance he gave me, prior to my departure for service in the Soudan, as by his kindness I brought a modification of his apparatus with me which enabled me to localize some deep-seated bullets with mathematical accuracy, and rendered their extraction simple and easy.

To Dr. Haughton, of Trinity College, Dublin, I am also much indebted, as under his kindly guidance I owe my first practical introduction to X rays.

Having recently had the pleasure of listening to his presidential address, on Roentgen ray work, at the opening meeting of the Biological Association in Trinity College, Dublin, and as part of my experience in the application of X rays to the practical needs of military surgery is so closely allied to his own, I am permitted to adopt his arrangement in the primary part of my paper.

To your honorary secretary, Dr. David Walsh, I am

also indebted for much valuable information, abstracted from his excellent treatise on this subject. I wish to avail myself of this opportunity of stating that wherever modern writers have suggested to me important views or practical information, I trust I have fully acknowledged my obligations.

To your telegram inviting me here to-night I confess I replied with probably too much haste, and, having answered in the affirmative, I found the task of selecting a suitable subject upon which to address you not too easy. However, I concluded you could not expect me to tell you anything about X ray work you do not already know, and consequently resolved to crave your indulgence, and ask you to permit me to dwell upon matters rather of a practical than scientific nature, which might probably be of use hereafter to junior officers of the royal corps to which I have the honour to belong.

I am in a position to state that most of our large military hospitals at home and abroad are now provided with a most efficient X ray outfit, and every inducement and encouragement are offered to officers by the Director-General of the Army Medical Service to acquire a thorough practical knowledge of this most important adjunct to our professional knowledge. Much doubt formerly existed as to whether the process was applicable to the arduous and ofttimes difficult requirements of field-service. Surgeon-Major Beevor, however, has demonstrated that successful results can be obtained in the cold and mountainous regions of Northern India, and only those who have a knowledge of that country can thoroughly appreciate the difficulties encountered, and the manner in which they were overcome. More recently it was my good fortune to be selected for service in charge of the Roentgen ray apparatus with the Nile Expeditionary Force in the Soudan, where the temperature varied from 100° to 122° F. in the shade. "Remember," wrote the principal medical officer of the Egyptian army, in answer to some information I asked for, "Beevor worked chiefly in cold regions: your efforts will be carried out in intense heat, where the temperature in tents is frequently over 120° F." I would like to state that whatever success attended my labours in the Soudan is largely due to the great care and attention bestowed upon the construction of the coils before they left London, and also the ready and able assistance I got from the warrant-officer of my own corps who was selected to help me.

Before leaving Cairo I took the precaution of having very thick felt covers made to surround the outer boxes containing the coils and storage batteries, and by keeping these constantly wet, the internal temperature was considerably reduced, as evaporation in the Soudan is very rapid. Between Wady Halfa and Abadieh all my apparatus had to travel for two days and a night in an open truck, exposed during the day-time to the fierce heat of a blazing sun. By keeping the felt wet every two hours, we reached our journey's end without mishap; thermometric observations later on proved that when the felt coverings were kept damp the temperature in the centre of the coil did not exceed 85 degrees.

With regard to Roentgen ray work, my experience has taught me that public, private, and official opinion is divided upon the results obtainable. Some I have met so confident of invariable success that they regarded the process equivalent to, and as easy as, putting a penny in the slot, when out comes a skiagram accurately demonstrating some abstruse problem in surgery, anatomy, physiology, or perchance psychology. Another and more difficult class to deal with are those who tell you decidedly that "they do not believe in the Roentgen rays," but even such I have succeeded in winning round to the same view I held, and finally heard them acknowledge "that the Roentgen rays are of invaluable assistance in localizing the exact position of bullets, and in many cases rendered probing of wounds unnecessary." A middle course is probably the safest for the critic to adopt, as undoubtedly there are many cases in which success is assured, and others in which much valuable information may be obtained, while at the same time a note of warning should be given not to expect too much in the more obscure regions of the body, or finer shades of pathological change. If it is permissible to draw conjectures of the future from observation of the past, we may almost prognosticate that the Roentgen rays will some day render to medicine services not less conspicuous than those already conferred upon surgery. Calcification of arteries can be demonstrated in the limbs; possibly with improved methods atheromatous changes may be shown in the heart and larger bloodvessels. Many difficulties have already been cleared up, by means of the fluorescent screen, regarding aneurism of the heart and of the first part of the aorta. Nor should it be impossible to detect the irregular outline of the upper and convex surface of the liver, when an abscess is pointing in that direction, towards the pleural cavity;

many of us, too, will know how difficult it is to accurately localize, for operative purposes, such an abscess.

Radiography can boast its most brilliant results in obscure injuries to bone, especially when the injured parts are too swollen to admit of careful examination by ordinary methods, or when such examination cannot be borne by the patient. Instead of long and painful manipulations by the surgeon, often ending in nothing better than a suspended judgment, he can, with the help of the rays, give a definite diagnosis and prognosis, and also gain in many cases much useful assistance as to his future treatment.

For our own reputation, and the welfare of our patients, many important conclusions would be arrived at if we invariably made it a routine practice to examine with the Roentgen rays every case, or suspected case, of fracture that came under our observation. Oberst of Halle, and Dr. Richardson of Boston, found as the result of such a systematic course of examination that, under ordinary treatment,

(1) Perfect union is rare;

(2) Oblique fractures generally have some overriding;

(3) In deep-seated bones there may be much bony deformity unrecognised;

(4) If fractional disturbance continues after treatment, overriding is the rule.

Nowhere has skiagraphy proved of greater practical value and assistance to the surgeon than in the detection and localization of foreign bodies. One condition alone is necessary—the foreign body must offer a resistance to the rays greater than that of the tissues in which it lies. Thus, a bullet buried in muscle or lodged in the lung casts a clear-cut shadow on the fluorescent screen, the image being somewhat obscure when lodged in more opaque structures, such as bone. Glass can be readily photographed, its opacity to the rays being due to lead and other materials necessary for its manufacture. The exact size, shape, and position of a needle in the hand or foot can now be readily demonstrated, when formerly it might have eluded not only the vigilance of careful manipulation, but even an extensive probing and cutting operation. Pins have been accurately localized in the larynx, and false teeth, buckles, and coins found in the œsophagus.

In military surgery the Roentgen rays have proved of great value, as lead is very opaque to the rays. The erratic course often taken by bullets after entering the body renders their discovery by ordinary means exceedingly difficult, if not in some cases quite impossible. After the Battle of Omdurman, 121 British wounded were conveyed to the surgical hospital at Abadieh. Of this number there were twenty-one cases in which we could not find the bullet or prove its absence by ordinary methods. In twenty out of these twenty-one cases an accurate diagnosis was arrived at with the help of the rays, the odd case, a severe bullet wound of the lung, being too ill at the time to examine. To confirm the beneficial results obtained by means of the Roentgen rays on field-service, it is satisfactory to quote the opinion of the senior medical officer in charge of the hospital, when he stated: "The Roentgen rays proved of invaluable assistance in localizing the exact position of bullets, and in many cases rendered probing of wounds unnecessary;" and, again, "the X ray apparatus has been found of inestimable value in this hospital in the treatment of the wounded. It has been applied to every case of gunshot wound in which the bullet was presumed to be lodged. Twenty-one cases in all were examined from the arrival of the wounded up to the present date. In many cases the X rays prevented much suffering to the patient which would have been caused by probing, the use of the finger, or enlarging the wound in the ordinary search for the bullet, as the skiagraph at once indicated the exact position of the bullet."

"In other more complicated cases the Mackenzie-Davidson method localized the exact position of the bullet, so that the surgeon was at once able to come to the conclusion if operative interference was judicious or otherwise. If considered advisable, the removal of the bullet was much facilitated by the diagram previously indicating exactly where the projectile was to be found."

I would like to augment this most satisfactory statement by a quotation from Dr. Haughton's address to the University of Dublin Biological Society, which testifies that "the X rays have furnished the army surgeon with a probe which is painless; which is exact; and, most important of all, which is aseptic — qualities not possessed by the older, though ingenious, instrument bearing Nelaton's name."

A bullet lodged in the right lung was beautifully seen with the screen in one of our patients at Abadieh, the shadow being equally visible whether examined from the front or back of the chest. So far as the abdomen is concerned, the results of skiagraphy in adults are, I think, uncertain or negative; but coins and other foreign bodies have been located in children.

That in certain cases a short exposure may give a better result than a long one has been my own experience, but my conclusions were deducted as the result of chance. Skiagraphing a skull for supposed bullet lodged about orbital region, I gave a fifteen minutes' exposure with a 10-inch Dean's coil. Not being satisfied with the result, I repeated my observation, when after seven and a half minutes the patient's head began to shake, and the coil was immediately stopped. To my satisfaction, I obtained an excellent plate.

In the Soudan some sixty observations were made by means of the screen and photographic plates, resulting in this conclusion: that each case had to be studied as a special problem with regard to the intelligent adaptation of detail and method.

The accurate localization (for practical surgical purposes) of foreign bodies in the tissues is, I think, the consummation of skiagraphic art. A bullet, for instance, in a loaf of bread can be localized with the fluorescent screen by means of acupuncture needles, but such a procedure is scarcely applicable to patients suffering more or less from shock and in a depressed and nervous condition. With a bullet situated in the upper or lower extremity, it is difficult from a single skiagraphic observation to say whether the projectile lies in front or back of the bone. A cross-skiagram, at right angles to the first, will at once solve the problem; and by this method most of our cases were localized in the Soudan. But for deeper structures my best results were obtained by the aid of a modification of Mr. Mackenzie-Davidson's localizing apparatus, which I brought out specially with me.

I shall now briefly deal with the application of the process to the requirements of field-service.

It is essential that our outfit should be made as light as possible, in order to be portable and suitable for mule, camel, or human transport, as often narrow defiles and mountainous passes have to be traversed. Another important item is that the constituent parts of our apparatus should be small enough to fit in paniers, to hook on either side of a pack-saddle on a mule's back. Our most serious difficulty at present is the best method of generating the primary electrical current for charging the storage batteries or working the coil direct. Primary batteries for many reasons are unsuitable, and not to be recommended. In the Soudan a small dynamo driven by means of a tandem bicycle answered admirably, and was readily transported by rail and river to our destination at Abadieh; but as at present constructed it is unsuited for mule, camel, or human transport.

An ideal apparatus would consist in a statical or friction machine — some modification, for instance, of Mr. Wimshurst's—by which the focus-tube could be excited direct. In such a design I am aware that many physical difficulties confront us, but are not insurmountable; I would therefore humbly ask your criticism and kind assistance concerning its attainment, as such an achievement would enable us to reduce our present apparatus very considerably, by dispensing with primary and storage batteries, dynamos, bicycles, and our induction coils.

The Roentgen ray outfit which was sent out to the Soudan consisted of a 10-inch coil, made by Mr. Dean, of Hatton Garden. This coil was specially insulated, and, with the condenser, commutator, interruptor, ammeter, voltmeter, small electric lamp, fluorescent screen, and two focus-tubes, was enclosed in a strong oak box. It was most complete and satisfactory, but for the requirements of field-service too heavy for camel or mule transport. Consequently I had a special arrangement of ropes made, by which means, and by the aid of a long pole, it could be carried on the shoulders of four men like an Indian dhoolie.

Another 10-inch coil, designed by Mr. Apps, also accompanied me. At my suggestion, this coil consisted of two separate parts, the coil proper being enclosed in a teak case, and the condenser, commutator, contact-breaker, etc., in another. By this method the weight was evenly divided, and the two boxes could be readily carried on either side of a mule or camel, or by coolies over very mountainous districts.

It is scarcely necessary for me to say that this coil gave entire satisfaction, as Mr. Apps' work is too well known to this Society to need any commendation from me. In addition, a small 6-inch Dean's coil accompanied me to Omdurman from Abadieh, the headquarters of our apparatus and base surgical hospital. I have already drawn attention to the thick felt covers I procured at Cairo, by which the internal temperature of the coils was much reduced by the process of evaporation, as these covers were constantly kept damp, and no doubt helped to preserve the insulating material of the coils.

The method by which we generated electricity I shall presently describe and illustrate by means of a photograph.

The storage battery consisted of eight separate E.P.S. cells, which proved more useful than having them

permanently fixed in a wooden case, as the voltage could be regulated, increased, or diminished as the case required; and also, should a cell become injured or a plate buckled, it could be taken out of the circuit at once and a spare one substituted. These cells when put in series answered admirably, but owing to the excessive heat the water evaporated rapidly from the acid solution, and a general lowering of the specific gravity of the electrolyte was noticed, presumably owing to the unusually high temperature at which the cells had to be worked.

In no case when the cells were fully charged did the hydrometer register a specific gravity of 1·22. This is an observation upon which I wish to lay stress, as in the absence of a voltmeter the exact condition of the cells when in use can only be judged by a hydrometer, the discharge being stopped when a specific gravity of 1·15 is recorded at 60° F.

A table of revised specific gravities for each increase of temperature above 60° F. for reference in warm climates is urgently required.

I brought four 10-inch ordinary bianodic focus-tubes with me. They were obtained from Mr. Dean, and personally tested by me before leaving. The platinum-wire terminals fused through the glass ends of the tube were protected by a ferrule of thick indiarubber, and each tube wrapped in cotton-wool and carefully packed in a small wooden box, which did not leave my personal supervision until I returned to Cairo in October. Two of these tubes did most excellent and extensive work, one being better for screen-work, while the other gave more satisfactory photographic results.

The fluorescent screen I found most useful at night, but unsatisfactory to work during the day owing to the intense sunlight, which, do what we could, seemed to penetrate the hood, no dark-room being available. The surface of the screen was protected by a layer of celluloid, which in a warm and dusty climate is a matter of no mean importance. The great advantage of screen-work in military surgery depends upon the fact that under suitable conditions we can explore any part of the body without delay. The greater perfecting, therefore, of our screen apparatus for daily work is a matter of much importance.

With regard to photographic materials and developers we had a good deal to learn. I may at the commencement state that glass plates alone gave satisfactory results, of which I had a variety of different sizes—Wratten and Wainwright's, Paget's, Lumière, and a small supply of Cadett Lightning. Those with the thinnest film appeared most suitable for the intense heat, but thick or thin, without the aid of an alum-bath I do not think we could have saved our plates, as the water for developing was comparatively hot, no ice being procurable, consequently the more delicate shades of development had to be sacrified. Of developers we used Rodinal, Hydroquinone, Metol, and Pyro. There was a marked tendency for development to proceed at a very rapid pace, often making the picture flash up at once, when the greatest precautions were necessary to preserve the result. As a rule, our developing work was performed at three o'clock a.m., and even then (the coolest time) the temperature in our mud-bricked dark-room varied from over 90° to 110°. An atmosphere laden with dust and constant dust-storms was most trying, eleven plates being destroyed one night by a fierce storm which blew off our improvised mud roof. I found "Tyler's dark bags" which I brought out with me most useful, as the wooden plate-holders are apt to shrink, and consequently light to gain admission.

Before leaving Cairo for the front, I fortunately discovered that the July heat, about 95° in the shade, was affecting the guttapercha insulated wire I brought out from home, the insulating material of which commenced to crack in different places. It was my good fortune during some of my rambles in the city of Cairo to make the acquaintance of a Monsieur Maroni, electrical engineer of Cairo, and through his kind assistance I obtained from the Telephone Company some Italian-made insulated wire of different grades, similar to that used throughout Cairo. This wire answered admirably, and withstood the heat splendidly.

The PRESIDENT congratulated the Society on the excellent results that had been brought about by the use of the Roentgen rays, which showed that it was possible to obtain these even under the most difficult circumstances. It would be possible in future to get rid of many difficulties of diagnosis in the field, such as distinguishing between dislocations and fractures, localization of bullets, etc., which in former days could not be settled so readily. Warfare under these circumstances would perhaps become less severe than in former days. He thanked Major Battersby in the name of the Society for the communication.

Surgeon-Major BEEVOR congratulated Major Battersby on the successful work which he had carried out with

the X rays. Having been in three campaigns, he was acquainted with some of the difficulties met with in military surgery. In the recent Frontier War in India, where they had several hundred wounded men, he had been able to test the practical value of the X rays. One case in particular might be mentioned, that of a man who was wounded in the right side; the bullet had entered between the ninth and tenth ribs, and had apparently penetrated partly through the liver and was lost. A long probe had been passed into the wound, but the position of the bullet could not be determined. But when the patient was brought to the base-hospital, by the aid of the X rays they found it lodged on the left side. The results obtained by Major Battersby showed that the X ray apparatus could be worked successfully in hot climates. In the Indian Frontier War most of the work was done during very cold weather among the mountains. They had one accident with the induction coil at starting, when the paraffin-wax was melted during transit in the railway train, and wet blankets were resorted to to keep the coil cool. Major Battersby was to be congratulated on the successful application of the "bicycle" to the driving of the dynamo. Soldiers were always willing to help in any way with the X ray apparatus; and if men were found to do the charging, there would not be any difficulty in the use of this method of obtaining current. There were some points connected with the practical working of the X ray apparatus concerning which the opinions of the members of the Society would be valuable. As to the length of spark, it seemed that the best penetration was obtained with a long, slow spark, while for screen-work a quick, short spark was better. As regards photographic apparatus, what was the most portable and convenient arrangement, also what were the best plates, or papers, or films for very hot or very moist climates? The films which he had tried seemed to absorb moisture.

Surgeon-Major KILKELLY, Grenadier Guards, said he had employed a small dynamo direct for working a 6-inch coil, driven by hand, and suggested that for developing plates a portable "dark-room" might be used, with a suitable aperture fitting round the operator's eyes so as to avoid some of the difficulties connected with developing tents and huts. He would be glad to know whether Major Battersby had had any experience with these, and whether he had also worked the coil direct from the dynamo when driven by the "bicycle" arrangement.

Professor S. P. THOMPSON said Major Battersby's experiences raised several points that were of interest to the physicist and to the instrument makers. Would it be possible to use the influence machine instead of the induction coil? and, if so, what would be the most convenient size and shape for the machine so that it might be portable. As to the materials for the plates, would ebonite be more suitable than glass? Would it stand the climate? Would the cylindrical form be better than the one usually used with plates? As to the films for the photographs, would it be possible to use mica for these instead of celluloid?

Mr. WILSON NOBLE said, with reference to Major Beevor's question as to the length of the spark, he found that a battery might be employed of double the E.M.F. usually recommended, and that this would give the best results; in this way a quick spark and a thick one was obtained. The tube should show no blue cloud when working, and should have a low resistance. He had recently obtained a radiograph of a shoulder showing bones and tendons by using a tube which took a heavy spark 3 inches long. As to films, they would not give the same density as plates. He had obtained the best results with Lumière plates; and these might be recommended if the long time required for developing them were no objection.

Mr. WEBSTER recommended the heating of the tube with a spirit-lamp when it could be obtained. The tube should be heated behind the cathode; it ought not to show any blue cloud when the anode was red-hot; a red-brown phosphorescence would appear behind the anode. For developing in a hot room of 90°, he had found amidol the best developer, and suggested this for use in hot climates.

Mr. E. PAYNE congratulated Major Battersby on the successful application of the "bicycle" method of driving the dynamo; some months back he had suggested in a note in the ARCHIVES that such a method might be possible. He was very pleased to see that someone else had not only thought of the same idea, but had really carried it out, and shown it to be used as a practical method of working the dynamo. With regard to the difficulty of using warm water in very hot climates, might it be possible to work a small freezing-machine with the aid of the "bicycle," not necessarily for the production of ice, but for reducing the temperature of the fluids used for developing, etc. With reference to influence machines, it ought to be possible to make the

machine portable by having the plates packed separately from the case and other working parts.

Mr. LESLIE MILLER said, with reference to the questions that concerned the manufacture of apparatus, special methods would often be employed by makers if they knew exactly the kind of work that was required. It was not necessary to use paraffin-wax, for instance, if the coil was to be used in hot climates. With reference to the accumulators and the evaporation of the liquid, they might be more covered in and prepared especially if their destination were known. With regard to the sensitized papers for taking radiographs, the Eastman paper had been used successfully during the recent Greek War.

Mr. GAIRDNER said that from his experience of different spark-lengths, he did not think the latter made very much difference. He thought it better to have a set of three or four tubes of different vacua, and not to resort to heating the tube. The suggestion of Professor Thompson that mica might be employed instead of celluloid for the photographic films was a very good one; there was a want of adhesion between the celluloid and the sensitive film.

Major BATTERSBY, in reply, said that he had not as yet tried to work the coil direct from the dynamo. With regard to the use of black material for a dark tent or bag, it would require a material that was proof against the very brilliant sunlight—perhaps two or three layers of black velvet would keep out the light. As to the size and portability of an influence machine, since guns could be carried, he did not see any reason why it should not be possible to carry an influence machine equally well. He thanked the different members for the information they had given with reference to the practical working of the tubes, and expressed his gratitude to the meeting for the reception that had been accorded to him.

A vote of thanks to Major Battersby, proposed by the PRESIDENT, was then carried unanimously.

Dr. C. Thurston Holland's paper on the Effects of X Rays will appear in the April number, with the photographs which have been unavoidably crowded out. —EDITORS.

FURTHER OBSERVATIONS ON THE PROPERTIES OF X RAYS.

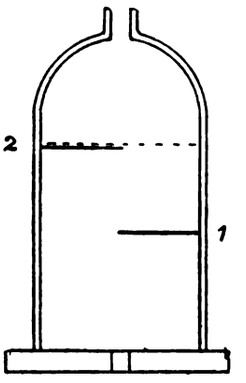
By W. C. ROENTGEN.

(*Third Communication to the Royal Prussian Academy of Sciences, Berlin.*)

Translated by permission from "Annalen der Physik und Chemie."

1. IF we have a discharge apparatus emitting intense X rays, and place between it and a fluorescent screen an opaque plate in such a way that the screen is entirely in shadow, we shall still observe illumination of the barium platino-cyanide. The illumination is still visible when the screen is placed directly against the opaque plate, and one is at first disposed to think that the plate is transparent. If, however, the screen, lying against the plate, is covered with a thick sheet of glass, the fluorescent light becomes much weaker, and disappears entirely if, instead of the glass, we surround the screen with a cylinder of lead 1 cm. thick, which is closed at one end by the opaque plate, and at the other by the head of the observer.

The effect just described might be due to the deflection of rays of very long wave-lengths, or to X rays emitted by bodies in the field of the discharge apparatus, such as the air.



The latter explanation is the correct one, as may be readily shown by the apparatus about to be described. The figure represents a thick bell-glass, 20 cm. high and 10 cm. wide, closed by a thick zinc plate cemented to it. At 1 and 2 are fixed segments of sheet lead slightly larger than half the sectional area of the bell; X rays which enter the bell through an aperture in the zinc plate, covered with celluloid, are prevented from reaching in a direct manner the space above segment 2. On the upper side of this lead sheet is fixed a barium-platinocyanide screen, which almost fills up the entire area of the bell. The screen can neither be struck directly, nor by such rays as have undergone a single diffuse reflection from any hard substance (the glass walls, for example). Before each experiment the bell is filled with air free from dust. If X rays are allowed to

enter the bell, and in such a manner that they are intercepted by the lead plate 1, no fluorescence is observed on 2; only when, after tilting the bell, direct rays reach the space between 1 and 2 does the screen light up on the half not covered by the lead plate 2. If the bell is connected up to an aquatic air-pump, the fluorescence will be observed to diminish as the exhaustion proceeds; if air be admitted, the fluorescence again increases.

Since, then, as I found it, the simple contact with air on which the rays have just fallen does not give rise to any noticeable fluorescence of the barium-platinocyanide, we conclude, from the experiment just described, that the air when struck by the rays sends forth rays in all directions.

If our eyes were as sensitive to X rays as they are to light rays, a discharge tube would appear to us like a light burning in a room uniformly filled with tobacco-smoke; perhaps the colour of the direct rays would differ from those coming from the particles of air.

The question whether the rays emitted by the objects struck by the rays are the same as the direct ones, or, in other words, whether a diffuse reflection or an action resembling fluorescence is the cause of these rays, I have not as yet been able to decide. It can easily be shown that the rays emitted by the air are capable of photographic effects, and their effect often shows itself in a manner unwished for by the observer. To guard against this, which is often the necessary accompaniment of long exposures, we must protect the photographic plate with a suitable lead screen.

2. For comparing the intensity of the radiation from two discharge tubes and for many other experiments, I employ an apparatus constructed after the manner of a Bouguer photometer, and which for simplicity I will call a photometer. A rectangular piece of sheet lead, 35 cm. high, 150 cm. long, and ·15 cm. thick, is set up between wooden supports in the middle of a long table. On either side of the same stands a discharge tube, which can be moved along the table. On one end of the lead sheet is fixed a fluorescent screen in such a position that each half is lighted only by the vertical rays of one tube. In making measurements, it is adjusted so as to give equal brilliancy of fluorescence on both halves.

Some remarks on the use of this instrument may find place here. It must be mentioned that the adjustments are often difficult through the variations in the source of the rays.

The tube responds to every irregularity in the contact-breaker of the primary circuit; these will occur with the Deprez, and still more with the Foucault, contact-breakers; several repetitions of each adjustment are therefore required. Secondly, I should like to point out the conditions on which the brilliancy of a given screen depends which is struck by X rays, following in such rapid succession that the eye of the observer can no longer follow the intermittence of the radiations. This brilliancy depends upon (1) the intensity of the radiation proceeding from the platinum plate of the discharge tube; (2) very probably on the kind of rays which strike the screen, for it is not necessary that all kinds of rays should produce fluorescence of equal intensity (see below); (3) on the distance between the screen and the source of the rays; (4) on the absorption which the rays undergo in their path towards the barium-platinocyanide; (5) on the number of discharges per second; (6) on the duration of each single discharge; (7) on the duration and strength of the after-glow; (8) on the radiations thrown on to the screen from objects surrounding the discharge tube. To avoid errors, it should always be borne in mind that, generally speaking, the conditions are such as would be met with if we had to compare, with the help of fluorescent effects, two different coloured intermittent sources of light, which, surrounded by an absorbent veil, are set up in an opaque or fluorescent medium.

3. According to § 12 of my first communication, the spot in the discharge tube struck by the cathode rays is the point from which the X rays are emitted, and these spread out in all directions. It is of interest to examine how the intensity of the rays varies with the direction. For this experiment, discharge tubes in the form of a bulb are most suitable, with an evenly-ground platinum plate set at an angle of 45° to the cathode rays. Without further aid we recognise in the equally bright fluorescence of that half of the bulb opposite the platinum plate that very great variations of the intensity in different directions are not present, that at the same time Lambert's law of emissivity cannot hold in this case; and yet this fluorescence is produced for the most part by cathode rays.

To obtain more accurate results as to the intensity of radiation in different directions, various tubes were examined with the photometer; with the same object also I have exposed photographic films bent round in a semicircle (radius, 25 cm.), with the platinum plate as centre. In both experiments the inequality of thickness

at different places in the glass walls of the tubes had a very disturbing effect, since on this account the X rays going forth in different directions are obstructed in unequal degrees. It was possible, however, to equalize the effect of these inequalities by the interposition of thin sheets of glass.

This experiment shows that the radiation of a hemisphere constructed around the platinum plate as centre is equal almost up to the edge of the same. Until an angle of 80° was reached, I was not able to detect any diminution in the radiation; and even this diminution is relatively small, so that the greatest alteration in intensity appears between 89° and 90°.

I have not been able to detect any difference in the nature of the rays emitted at different angles.

In consequence of the above-mentioned distribution of intensity of the X rays, the pictures which are obtained with a pinhole camera—*i.e.*, with a narrow slit—whether it be on a fluorescent screen or on a photographic plate, must be so much the more intense the greater the angle which the platinum plate makes with the screen or the photographic plate, assuming that this angle does not exceed 80°. By the aid of special appliances, which permitted the comparison of pictures taken simultaneously at different angles with the same tube, I have been able to confirm this inference.

A similar case of distribution of intensity of radiation is met with in optics in the case of fluorescence. If we let fall into a four-sided tank filled with water a few drops of fluorescein, and illuminate the tank with white or violet light, we observe that the brightest fluorescent light emanates from the edges of the slowly-sinking threads of fluorescein, *i.e.*, from the points where the angle of emission of the fluorescent light is greatest. As Sir G. Stokes has pointed out in connection with a similar investigation, this appearance arises from the fact that the rays exciting fluorescence are more readily absorbed by the fluorescein solution than the fluorescent light. Now, we should specially note also that the cathode rays, which produce the X rays, are more readily absorbed by the platinum plate than the X rays. And from this the suggestion would readily follow that there exists a relationship between the foregoing, viz., the conversion of light into fluorescent light, and of cathode rays into X rays; there is as yet no conclusive ground on which such a supposition could be based.

With reference to the technique of the production of radiographs by the aid of X rays, the observations with regard to distribution of intensity of the rays emitted by the platinum plate are of some importance. For this reason it would be advisable to set up the discharge tube in such a position that the rays intended for the production of the picture may leave the platinum plate at the greatest possible angle—not, however, exceeding 80°; in this way the sharpest possible image is obtained, and if the platinum plate is smooth, and the construction of the tube such that the rays emitted obliquely have no thicker glass wall to penetrate than those emitted at right angles, the rays will suffer no loss of intensity through the adoption of the above arrangement of the apparatus.

4. By the "permeability of a substance" I denoted in my first communication the ratio between the brilliancy of illumination of a fluorescent screen held directly in front of the substance at right angles to the rays, and the illumination of the screen without the interposition of the substance, but otherwise under exactly similar conditions.

The specific permeability of a substance would be defined as the permeability of the substance with respect to unit thickness; the same is equal to the dth root of the permeability, when d denotes the thickness of the layer penetrated, measured in the direction of the rays.

To determine the permeability, I have employed chiefly, since my first communication, the photometer described above. Before one of the two halves of the screen, of equally bright fluorescence, was placed the substance to be tested in the form of a plate (aluminium, tinfoil, glass, etc.), and the resulting inequality of illumination brilliancy was again equalized, either by increasing the distance of the discharge tube illuminating the half-screen not covered, or by bringing the other nearer. In both cases the correct ratio of the square of the distances of the platinum plate from the screen before and after the adjustment of the apparatus is the required value of the permeability of the substance. Both methods lead to the same result. By the introduction of a second plate in addition to the first we determine the permeability of that second plate for rays which have just passed through one plate.

In the above it is assumed that the brilliancy of the fluorescent screen is inversely proportional to the square of the distance from the source of rays, and occurs only when, in the first place, the air does not absorb and afterwards emit any X rays, and when, secondly, the brilliancy of the fluorescent light is pro-

portional to the intensity of radiation by rays of the same kind. The first condition is certainly not fulfilled, and it is questionable whether the second is fulfilled. By means of the experiments described in my first communication (§ 10) I was convinced at the outset that the derivations from the law of proportionality alluded to are so small that they can be left out of account in the present case.

With respect to the fact that X rays are again given out by bodies on which the rays fall, it must be mentioned, first, that no difference could be detected with the photometer between the permeability of an aluminium plate ·925 mm. thick and that of thirty-one aluminium leaves, each ·0299 mm. thick, laid upon one another—$31 \times ·0299 = ·927$; and, secondly, that the brilliancy of the fluorescent screen showed no appreciable difference, whether the plate was held close to the screen or at a greater distance from it.

Permeability for Rays falling at right angles.	Tube 2.	Tube 3.	Tube 4.	Tube 2.
The first aluminium plate 1 mm. thick	·40	·45	–	·68
The second aluminium plate 1 mm. thick ...	·55	·68	–	·73
The first aluminium plate 1 mm. thick	–	·30	·39	·50
The second aluminium plate 1 mm. thick ...	–	·39	·54	·63

From these and similar experiments carried out with glass and tinfoil we draw the following conclusions: If we assume that the body under examination is divided into layers of equal thickness at right angles to the parallel rays, each of these sections is more transparent to the rays penetrating it than the layer above; or, in other words, the specific permeability of a substance is greater the thicker the body in question is.

This result is entirely in accord with what will be found in § 4 of my first communication with reference to a photograph of a tinfoil scale, and also with the fact that the shadow of thin layers (for instance, the paper used for wrapping up the plate) makes a comparatively strong impression in the photographic pictures.

5. When two plates, made of different substances, are equally permeable, this equality does not necessarily hold good, if the thickness of both plates is proportionately altered, other things remaining the same. This fact can be most easily demonstrated by the aid of two scales of platinum and aluminium placed side by side. For this purpose I employed platinum foil ·0026 mm. and aluminium foil ·0299 mm. in thickness. On placing the double scale before the fluorescent screen or on a photographic plate and submitting them to the rays, I found, for example, in one case that a single sheet of platinum was equal in permeability to six sheets of aluminium, but the permeability of a double layer of platinum was not equal to that of twelve, but of sixteen, sheets of aluminium. When another discharge tube was employed, I obtained 1 platinum = 8 aluminium, and 8 platinum = 90 aluminium. It follows from these experiments that the relation between the thickness of platinum and of aluminium of equal permeability becomes smaller the thicker the layers.

6. The relation between the thickness of two equally permeable plates of different substances is dependent upon the thickness and nature of the substance—for instance, the glass wall of the discharge tube—through which the rays have to pass before reaching the plates in question.

To test this result—which will not be unexpected, from what has been shown in §§ 4 and 5—an arrangement can be employed which I will call a platinum-aluminium window, and which can be used for other purposes, as will be seen. This consists of a rectangular piece ($4 \times 6·5$ cm.) of platinum foil ·0026 mm. thick, stuck down upon a thin paper screen and pierced with fifteen round holes, ·7 cm. in diameter, arrayed in three rows. These little windows are covered with small panes composed of layers of aluminium foil ·0299 mm. thick carefully fitted one over the other, so that there is one layer in the first window, two in the second, etc., and fifteen in the fifteenth.

When this apparatus is placed before the fluorescent screen it can clearly be estimated, with tubes that are not too hard (see below), how many aluminium leaves have the same permeability as the platinum foil. This quantity shall, for brevity's sake, be called the "window number."

In one case I obtained 5 as window number with direct radiation; a piece of ordinary soda-glass was then held before the screen, and the window number was then found to be 10; the relation between the thickness of the platinum and aluminium leaves of equal permeability was thus reduced to one half, since, instead of the rays coming direct from the discharge tube, I was now using those which had passed through a glass-plate 2 mm. thick, *q. e. d.*

The following experiment may also be mentioned here:

The platinum-aluminium window was placed upon a packet containing twelve photographic films and then exposed; after development the sheet lying next below the window showed the window number 10, the twelfth the number 13, and the remainder, the gap between 10 and 13, in correct order.

7. The experiments described in §§ 4, 5, and 6 refer to the changes which the X rays from a discharge tube undergo when passing through different substances. It will now be shown that one and the same substance, when pieces of constant thickness are used, may have different permeability for rays emitted by different tubes.

In order to show this, I have given in the following table the values of the permeability of an aluminium plate 2 mm. thick for rays produced by different tubes. Some of these are taken from the first table in § 4:

	Tubes.					
	1.	2.	3.	4.	2.	5.
Permeability for rays falling at right angles of an aluminium plate 2 mm. thick	·0044	·22	·3	·39	·5	·59

The discharge tubes did not differ materially in their construction or in the thickness of the glass walls, but chiefly in the degree of exhaustion of the gases contained, and in the potential of discharge dependent thereon. Tube 1 required the lowest, tube 5 the highest, potential of discharge, or, as we will say, for the sake of brevity, tube 1 is the "softest," tube 5 the "hardest." The same induction coil, and also the same direct connection with the tubes, the same contact-breaker, and the same primary current, were used in every case.

Many other substances tested behaved in a similar manner to the aluminium; all are more permeable to rays from a hard tube than to rays from a soft tube.* This fact seems to me worthy of special attention.

The relation between the thickness of two equally transparent plates of different substances appears to depend upon the "hardness" of the discharge tubes employed. This is at once recognised with the platinum-aluminium window (§ 5); when, for example, the window-number 5 is obtained with a very soft tube, for very hard but otherwise similar tubes the scale reading up to 15 is not high enough. That is to say, the relation between the thickness of platinum and aluminium of equal permeability is less the harder the tubes are from which the rays proceed, or, with respect to the result obtained above, the less absorbable the rays.

* For the relations of tube not normal see § 8.

The different behaviour of the rays produced in tubes of different hardness naturally shows itself also in the familiar radiographs of hands, etc. With a very soft tube a picture is obtained in which the bones are only partially shown; by employing a harder tube the bones become very clear and visible in every detail; and with a very hard tube only very weak shadows of the bones are obtained. From what has been said, it follows that the choice of tubes must be regulated by the composition of the object to be radiographed.

8. It still remains to be pointed out that the quality of the rays given out by one and the same tube is dependent upon different circumstances. As we learn from the investigation with the platinum-aluminium window, this quality is influenced by—(1) The way in which the Deprez or Foucault contact-breaker* on the induction coil works — *i.e.*, the fall of the primary current. In this place we may notice the phenomenon often observed that single discharges rapidly following one another produce rays which are not only specially intense, but which are distinguished from others by their absorbability. (2) By a spark gap which is thrown into the secondary circuit in series with the discharge tube. (3) By the insertion of a Tesla apparatus. (4) By the degree of exhaustion of the discharge tube (as already mentioned). (5) By different conditions in the interior of the tube not yet sufficiently understood. Some of these factors deserve to be examined more closely.

If we take a tube not yet used or exhausted and seal it on to the mercury pump, after the necessary pumping and warming, we shall reach a point of exhaustion at which the first X rays begin to show their presence by the weak illumination of the fluorescent screen, held close to the tube. A spark gap in parallel with the tube allows sparks to pass off only a few millimetres in length, the platinum-aluminium window shows very low numbers, the rays are very absorbable. The tube is very "soft." If a spark gap is now inserted in series or a Tesla transformer† is put in circuit, more intense and less absorbable rays are emitted. Thus, for instance, in one case I found that by lengthening the spark gap in series the window-number could be increased from 2·5 to 10. (These observations have led me to the question whether X rays may not be obtained at lower vacua by the

* A good Deprez contact-breaker works more regularly than a Foucault contact-breaker; but the latter uses the full value of the primary current more completely.

† In the French edition of my second communication (*Archives des Sciences physiques*, etc., de Genève, 1896) I mentioned that a spark gap in series has an effect similar to that of a Tesla transformer. By oversight, this was omitted from the German edition.

employment of a Tesla transformer. This is, in fact, the case; with a narrow tube with wire electrodes I was able to obtain X rays when the internal pressure of the air was 3·1 mm. Hg. If hydrogen were used instead of air, the pressure might be greater. I could not definitely determine the lowest pressure under which X rays are produced in air; it lies, at all events, below ·0002 mm. Hg., so that the range of vacuum within which X rays can be produced is very wide.)

Further exhaustion of very soft tubes (in direct connection with the coil) has the effect of causing more intense radiation, and a larger portion of the rays penetrates the substance on which they fall. A hand held before the fluorescent screen appears more permeable than before, and higher window-numbers are given for the platinum-aluminium window. At the same time, the spark gap in parallel must be increased to allow the discharge to pass through the tube; the tube has become "harder." After still further pumping, the tube becomes so hard that the spark gap must be made over 20 cm. in length, and the tube now gives out rays for which substances are exceedingly permeable; iron plate, 4 cm. in thickness, proves to be permeable when examined with the fluorescent screen.

This is the normal behaviour of a tube when connected with a mercury pump and induction coil. Deviations from this rule, which are brought about by the discharges themselves, are of frequent occurrence. The behaviour of the tube is often quite unaccountable.

The "hardening" of a tube appeared to be brought about by the continued exhaustion on the pump, but this can occur in other ways. Thus a tube of moderate hardness sealed off the pump becomes increasingly harder of itself—unfortunately with regard to the duration of its applicability—if it is employed in the proper manner for the production of X rays; that is to say, when discharges are sent through it which either do not heat the platinum to redness, or only slightly so. A general self-exhaustion takes place. With a tube that had become in this way very "hard" I have obtained a very fine radiograph of the double barrel of a gun loaded with cartridges, in which every detail of the cartridges, the flaws in the steel of the barrel, etc., are very clearly and sharply shown. The distance of the platinum plate from the photographic plate was 15 cm. and the time of exposure twelve minutes—long in proportion on account of the weak photographic action of the rays which are only slightly absorbed (see below). The Deprez contact-breaker had to be replaced by the Foucault. It would be of interest to construct tubes that would admit the application of a higher potential of discharge than has as yet been possible.

The self-exhaustion of the tube following the discharges was assigned as the cause of "hardening"; this is not, however, the only cause. Changes take place at the electrodes which produce similar results. I do not know how to account for them.

A tube that has become too "hard" can be made "softer" by the admission of air, or often by warming the tube, or by reversing the direction of the current, and finally by sending very strong discharges through it. But in the last case the tube will have acquired other properties, such as those previously described; thus, for instance, it will often require a very high potential of discharge, and yet give out rays of comparatively low window-numbers and great absorbability. I will not go further into the questions connected with these abnormal tubes. The tubes made for me by Herr Zehnder with adjustable vacuum, which contain a small piece of lime-wood-charcoal, have been very serviceable. The observations described in this section, together with others, have led me to the conclusion that the composition of the rays from a discharge tube provided with a platinum anode is essentially dependent upon the transient nature of the discharge current. The degree of attenuation, the hardness, has an effect only on this account, since the form of discharge is dependent upon it. If we can in any way produce the form of discharge necessary for the production of X rays, we shall be able to obtain X rays even under comparatively low vacua.

Finally, it is worth mentioning that the quality of the rays given out by a tube is not at all, or only slightly, affected by any considerable alterations in the strength of the primary current, provided that the contact-breaker maintains a constant action in all cases. On the other hand, the intensity of the X rays shows itself to be, within certain limits, proportional to the strength of the primary current, as the following experiment shows. In a particular case the distances from the discharge tube at which the fluorescence of the barium-platinocyanide screen was just visible were 18·1, 25·7, and 37·5 metres, when the strength of the primary current was raised to 8, 16 and 32 ampères. The squares of these distances are in almost the same proportion to one another as the corresponding current values.

9. The results brought out in the five preceding

sections followed immediately from the separate experiments described. If these individual results are considered together, we shall arrive at the following conclusions, partly through the analogy which prevails between light rays and X rays:

(*a*) The radiations proceeding from a discharge tube consist of a mixture of rays of different absorbability and different intensity.

(*b*) The composition of this mixture is essentially dependent upon the transient duration of the discharge current.

(*c*) The rays intercepted by absorption are different for different substances.

(*d*) Since the X rays originate from the cathode rays, and both have the same properties—causing of fluorescence, photographic and electrical actions, and absorbability, the extent of which depends upon the density of the medium through which they pass, etc.—we are led to surmise that both appearances are phenomena of the same nature. Without wishing to commit myself unconditionally to this view, I should like to point out that the conclusions arrived at in the preceding sections tend to raise a difficulty, which appears up to the present to be in opposition to this conjecture. This difficulty consists, first, in the great difference between the absorbability of the cathode rays, investigated by Herr Lenard, and that of the X rays; and, secondly, in the fact that the permeability of substances for these cathode rays depends upon the density of the substances, according to a law other than that relating to the permeability for X rays.

With respect to the first point two things should be considered. (1) We have seen in § 7 that there are X rays of very different absorbability, and we know from the researches of Hertz and Lenard that the different cathode rays are distinguished from one another according to their absorbability; consequently, therefore, if the softest tube mentioned in § 7 emits X rays whose absorbability does not extend nearly so far as that of the cathode rays investigated by Lenard, there are, no doubt, X rays of greater, and cathode rays, on the other hand, of lesser, absorbability. It seems highly probable that rays will be found, after further investigation, which, as regards their absorbability, will bridge over the gap from one kind of ray to the other. We found in § 4 that the specific permeability of a body is less the thinner the plate employed. Had we, therefore, taken for our experiment plates as thin as Herr Lenard's, we should then have found values for the absorbability which would approach near to the Lenard rays.

With regard to the different influence of the density of substances on the absorbability of X rays and cathode rays, it must be mentioned that this influence will be found to be smaller the more absorbable the rays are which we select for the experiment (§§ 7, 8), and the thinner the plates employed. The possibility must consequently be admitted that this difference in the behaviour of both kinds of rays, as also that mentioned before, can be brought to a vanishing point by further experiments.

In their behaviour with respect to absorption, the nearest relation subsists between the cathode rays present in very hard tubes and the X rays proceeding from the platinum plate in very soft tubes.

10. Besides giving rise to fluorescence, the X rays, as is well known, produce photographic, electric, and other effects. And it is of interest to know how far the same move parallel with one another when changes take place in the source of the rays. I have been obliged to confine myself to the comparison of the two first effects.

Here, again, the platinum-aluminium window is well adapted for the purpose. One of these was placed upon a photographic plate protected from the light, while a second was held before the fluorescent screen, both being placed at the same distance from the discharge tube. The rays had to pass through exactly the same medium to reach the plate and the screen respectively. During the exposure I watched the fluorescent screen and noted the window-numbers; after development the window-numbers were likewise determined on the photographic plate, and then both numbers were compared. The result obtained shows that when "soft" tubes are employed (window-numbers 4 to 7) no difference is observed; when hard tubes were employed, it appeared to me that the window-number on the photographic plate was a little lower, at the utmost one unit, than that shown by the fluorescent screen. The observation, however, though confirmed by repetition, is not free from exception, since the determination of high window-numbers on the fluorescent screen is somewhat uncertain.

The following result, however, is entirely reliable. If we place on the photometer described in § 2 a hard and a soft tube which give equal brilliance on the fluorescent screen, and then substitute a photographic plate for the screen, we shall find, after development of the plate, that the half acted upon by the hard tube is not so dark as the half acted upon by the soft tube. Rays which will

produce the same intensity of fluorescence do not produce the same photographic effect.

In forming an opinion from these results, we must not lose sight of the fact that neither the fluorescent screen nor the photographic plate entirely absorb the rays falling on them; both allow a considerable quantity of the rays to pass through them, which may produce fluorescent and photographic effects respectively. Accordingly, the result given holds good only for the usual thickness of the sensitized photographic film, and the layer of barium-platinocyanide. The following experiment shows how very permeable the sensitized photographic film is for X rays from a tube of medium hardness: 96 films were exposed for five minutes at a distance of 25 cm. from the source of the rays, and protected from radiations in the air by a lead cover. A photographic effect could be distinctly recognised on the last film, while the first was scarcely over-exposed.

Incited by these and similar observations, I have made inquiries from some firms supplying photographic plates as to whether it were not possible to produce plates which were more suitable for X rays than the ordinary ones. The specimens, however, sent to me were not suitable.

I have often had the opportunity of observing (as stated in § 8) that very hard tubes, under otherwise equal conditions, require a longer exposure than those of medium hardness. This will be understood when we remember the results given in § 9, that all substances investigated for rays emitted by hard tubes are more permeable than those given out by soft tubes. And, owing to the lesser intensity of rays emitted from soft tubes, it will be understood that a long exposure must again be given.

When the intensity of the rays is increased by the increase of the current strength in the primary circuit (*cf.* § 8), the photographic effect is intensified to the same degree as the intensity of fluorescence; and in this case, as well as that above mentioned, where the intensity of the radiation acting on the fluorescent screen is changed by the alteration in the distance of the screen from the source of the rays, the brilliancy of fluorescence would be proportional, or nearly so, to the intensity of radiation. This rule cannot be applied, however, in all cases.

11. In conclusion, I may be permitted to mention the following particulars. In a properly constructed discharge tube, not too soft, X rays proceed chiefly from a spot, 1 or 2 mm. in size, on the platinum plate struck by the cathode rays; at the same time, this is not the only point of emission: the whole plate and a part of the walls of the tube emit X rays, though in a much weaker degree. Cathode rays, namely, proceed from the cathode in all directions, but the intensity of the same is strong only in the neighbourhood of the axis on the concave side, and hence the most intense X rays originate on the platinum plate where the axis meets it. When the tube is very hard and the platinum thin, a number of rays proceed from the back of the platinum plate, and chiefly, again, from a spot lying on the axis, as shown by the pinhole camera.

In these hard tubes also the cathode rays of maximum intensity can be deflected from the platinum plate by a magnet. Some observations made with soft tubes induced me to go once more into the question of the magnetic deflectibility of X rays with improved apparatus. I hope soon to give some reports of these experiments.

I have continued the experiments mentioned in my first communication on the permeability of plates of equal thickness which are cut in different directions from one crystal. Observations were made with plates of calc-spar, quartz, tourmaline, beryl, aragonite, apatite, and baryte. No effect on the permeability was observed from this direction.

I have verified the fact stated by Herr G. Brandes that the X rays can excite a sensation of light in the retina of the eye. In my journal there is a note at the beginning of November, 1895, that I observed in a dark room near a wooden door, on the outside of which a Hittorf tube was fixed, a weak appearance of light, which spread over the whole field of vision when discharges were sent through the tube. As I observed this phenomenon only on one occasion, I considered it subjective, and observed no repetition of it because other tubes were used subsequently instead of Hittorf's, having lower vacua and not being fitted with platinum anodes. The Hittorf tube gives rays of low absorbability on account of the high exhaustion and intense rays owing to the presence of a platinum anode impinged upon by the cathode rays, which would favour the production of the appearance of light in question. I was obliged to replace the Hittorf tubes by others, as they punctured after a short time.

With the sensitive hard tubes now in use Brandes' experiment can be easily repeated. The following description of a series of experiments is of interest: If

you place as near as possible before the eye, open or closed, a piece of metal with a vertical slit in it less than 1 mm. wide, and bring your head, covered with a black cloth, close to the discharge tube, a weak streak of light will be observed, after a little practice, which will vary in form—straight, crooked, or circular—according to the position of the slit before the eye. By slow movement of this slit in a horizontal direction these different forms can be made to merge gradually into one another. An explanation of this phenomenon is soon found if we remember that the eyeball is pierced by a sheaf of X rays, and realize that the X rays can give rise to fluorescence in the retina of the eye.

Since the commencement of my work on the X rays I have repeatedly endeavoured to obtain diffraction of these rays. On many occasions I met with phenomena, with narrow slits, which suggested diffraction images in outward appearance, but when, after changes were made in the conditions of the experiment, I could test the accuracy of the explanation that the images were due to diffraction, this proved not to be the case; and I was often able to show directly that the phenomena arose from quite other causes than diffraction. I cannot record any experiment from which I could feel convinced of the existence of a diffraction of the X rays.

Würzburg, Physik. Institut. d. Univ., March 10, 1897.

Abstracts.

ROENTGEN RAY DERMATITIS.

Abstract of paper in the American X ray Journal, vol. iii., No. 5, by CHARLES LESTER LEONARD, M.A., M.D. of Philadelphia.

In accounting for the inflammatory reaction and devitalization of tissue, we must first prove that they are not due to well-known electrical effects before we attribute them to an unknown action of the Roentgen rays.

"The physiological study of the action of electric currents shows that at first they stimulate nutrition, but if employed for too long a period or in too great strength they devitalize, and destroy the tissues upon which they act. The long period that elapses before the effects are shown, and the longer period that follows before these injuries are healed, are strong clinical evidence that it has been a devitalizing agent that has interfered with nutrition and produced the pathological changes."

"Referring to the experiments of Kummel in Hamburg on the treatment of lupus, the writer points out that his best results were obtained by short frequently repeated exposures that never resulted in dermatitis; *i.e.*, stimulation without devitalization was required. The therapeutic action described by Schiff and Freund, of Vienna, was most effective when a tube was used requiring low ampèrage and voltage, and at such a distance that the devitalizing action of the static field could not be exerted. The electrostatic field was then less intense. This supports the writer's opinion and coincides with his experience. Deleterious effects were not produced until the writer's coil was re-wound, so as to give a secondary current of high ampèrage. An aluminium screen, attached to a grounding-wire, prevented further injury. In two cases where it was desired to produce a therapeutic effect the action of the screen was sharply illustrated. When it was employed and static currents were conducted to earth, no 'burn' was produced. On the other hand, when it was omitted, the static charge collected in the patient, and a deep necrosis was the result of the devitalization of the tissues; all other conditions remained the same. In the writer's opinion, static electric currents are capable of producing all the therapeutic and destructive changes ascribed to the Roentgen ray; and as the static charge is always present, there is no need to ascribe the action to the rays."

ROENTGEN RAY BURNS.

Abstract of paper in the American X ray Journal, vol. iii., No. 5, by Professor ELIHU THOMSON.

The writer repeats his first opinion, that the burns are produced chiefly by those rays of the X ray order which are most readily absorbed by the flesh. Such rays are sent out in large amount when the vacuum is low, or when the tube is "soft." The rays from a tube with high vacuum pass through flesh, and, not being absorbed by the skin, cause no injury.

The idea that the trouble is due to electrostatic discharges was disposed of by the writer nearly two years ago, when, having made an experiment with the little finger of the left hand, with quite severe results, he repeated the experiment with modifications on the adjoining finger. This was protected by sheet-lead, which had a window in it to limit the effect to a small elongated spot. This window was divided by a strip of tinfoil which lay close to the finger, and in one of the divisions so made the finger was covered by a double layer of aluminium foil, the other division being left bare. An exposure to a special tube was followed in ten days by two small burns: one on the part which had been under the aluminium foil, and the other on the bare spot.

It is inconceivable that any electrostatic effect could have acted through the aluminium more than through the tinfoil or sheet-lead, as all was in electrical contact. Electrostatic effect or electro discharges were clearly ruled out. The writer also caused a burn by exposing his little finger to a tube excited by an influence machine.

The action of the rays on a sensitized plate or fluorescent screen is due to energy absorbed, producing chemical action and light respectively. The injuries to the skin are in like manner due to energy absorbed, and those rays which pass through the flesh freely are doubtless incapable of doing any injury.

Description of Plates.

Before demonstrating some of my achievements in the Soudan I would crave your indulgence, and ask you, an eminently critical audience, to review my efforts with a friendly criticism, as it was not contemplated that my work (which was performed under great climatic difficulties, and solely and purely for practical surgical purposes) should ever aspire to the coveted position of public demonstration.

As the result of my practical experience in the Soudan, I think I may safely counsel any of my friends who are anxious to visit that country either for pleasure or scientific pursuits, not to do so, of their own free will and accord, during the months of July, August, and September, when the temperature varies from 100° to over 120° F. in the shade, and dust-storms almost cyclonic in their character are of daily or nightly occurrence.

My headquarters were at Abadieh, a small village on the Nile, about 1,250 miles from Cairo and 9 miles north of Berber. Here the Egyptian troops had constructed a number of large, well-ventilated and mud-bricked buildings, which admirably suited all the requirements of a large surgical hospital in the field.

After the battle at Omdurman we brought back wounded to Abadieh 121 British officers, non-commissioned officers, and men. Of this number there were 21 cases that could not be diagnosed accurately by ordinary surgical means. By the help of the Roentgen rays, which were used about sixty times, we found the bullet, or proved its absence, in 20 out of these 21 cases —the odd case being so ill with a severe bullet wound of the lung that it was not considered justifiable to examine him at the time.

In order to avoid unnecessary pain and disturbance to the patient, suffering a good deal from shock, my skiagrams were invariably taken without interfering with any of the dressings. Consequently, such substances as iodoform and the perchloride of mercury preparations interfered materially with our skiagraphic effects, but not with our practical diagnosis and surgical results.

PLATE LVII. (*a*).

My first picture will show you the Nile at Abadieh, and is interesting, being probably the first photograph ever taken and developed in this part of the world, as, shortly before our arrival, the whole district was more or less in the hands of the Dervishes. The river here is about three-quarters of a mile broad, and in colour not unlike the Thames as it flows under Westminster Bridge. Such was the water for cooking and drinking purposes, and the development of photographic plates—not an easy matter, when the temperature in the shade was 110°, and no ice to cool the water procurable. A gyassa, or native boat, is seen fighting its way against the current towards Atbara, most probably conveying commissariat stores for use on the march to Khartoum, for by similar boats were most of our stores brought to the advanced depot at the front.

PLATE LVII. (*b*).

This photograph shows you the method by which we generated electricity for charging the storage batteries which worked our induction coils, and illuminated the lonely desert for the first time with electric light, after our "specially prepared candles" had been resolved by the excessive heat into their oily constituents. You can see that the pulley of a small dynamo is connected by means of a leather strap with the back wheel of a specially-constructed tandem bicycle. The required velocity for the dynamo was thus obtained, and our procedure was as follows: Having carefully adjusted the circuit with the storage battery, and also with the voltmeter and ammeter, my warrant-officer took his position on the seat of the bicycle which you see in the picture and commenced pedalling. When 15 volts and 4 ampères were registered, the switch close to the handle of the bicycle was opened, and charging of battery commenced. As the resistance became greater a sensation of riding uphill was experienced, and the services of an additional orderly requisitioned for the front seat. This bicycle practice was generally carried out in a shade temperature of 110° F. So that at the end of half an hour we unanimously agreed that some other form of scientific

amusement was desirable. Then, the switch having been turned off before pedalling ceased, in order to avoid any discharge from the battery, the machine was brought to a standstill.

Our cells were the ordinary E.P.S. cells, 40 ampère hour type, with a voltage of 2 volts per cell, and a discharge of 4·5 to 6 ampères. The cells while being charged required the dynamo to give a current of 15 volts and 6 ampères; this multiplied together gives an electromotive force of 90 Watts, and as 760 Watts equal 1 electric horse-power, $\frac{1}{8}$ horse-power was necessary to drive the dynamo for charging. It was also necessary to have an extra $\frac{1}{8}$ horse-power to overcome the resistance of the working parts and the opposing force contained in the full batteries; hence the necessity of tandem-seat for extra man.

A happy hint for further development is here given to the many possessors of bicycles in this electrical age, that, with a little mechanical ingenuity and by removing the tyre from the back wheel, one and all may at any time and in any place start a small installation on his own account.

Never was the old adage as to "necessity being the mother of invention" more fully exemplified than at Abadieh, where nothing but sand and dirty water could be obtained. And whether the Egyptian Government will ever call upon me officially to return the few purloined wooden railway sleepers upon which you see my bicycle and dynamo are fixed is a matter that does not much concern me now. A far greater personal loss was the dedication of a new flannel-shirt for the protection of my dynamo from dust, from a field-service kit necessarily not too large.

PLATE LVIII. (*a*).

Here you see our 10-inch coil at work, which has been specially insulated and enclosed in a strong oak box; the storage battery is connected with the coil, and a modification of Crook's tube suspended by means of an ingenious tube-holder over the shoulder-joint beneath, which is a photographic plate encased for greater protection in wooden light-tight plate-holder.

PLATE LVIII. (*b*).

This illustrates a modification of Mr. Mackenzie Davidson's localizing apparatus, by means of which I was enabled, with mathematical accuracy, to localize two bullets which had entered through the shoulder, and lodged in each case near the shoulder-blade. Another bullet was localized with similar precision in the pelvic cavity. The patient, a private in the Seaforth Highlanders, while standing half-right firing at Omdurman, was hit about 1 inch behind and 1 inch below the anterior superior spine of his left ilium. When examined at night with the screen, the lateral view distinctly showed the bullet, which next day was localized. The vertical depth from the surface to the centre of the tip of the bullet was $1\frac{3}{4}$ inches, and centre of base of bullet 2 inches, so that the depth, direction, and exact position of the bullet were told to the operating surgeon.

PLATE LIX. (*a*).

Private H., 2nd Rifle Brigade, bullet-wounds through outer and inner side of left arm, and a third wound near inferior angle of left scapula. Three pieces of bullet found at outer side of humerus. No bullet seen in chest, consequently no necessity to probe for it.

PLATE LIX. (*b*).

This faint skiagram, taken through the chest without removing the dressings and bandages, illustrates one of the cases I have already referred to. Private J. B., Royal Warwickshire Regiment, received a bullet-wound near the tip of right shoulder, behind the acromial end of his clavicle. Front view revealed the bullet at right angles to axillary border of scapula, about 2 inches below glenoid cavity, outer tip of bullet just touching axillary edge, probably in subscapular space. This case was localized by Mr. Mackenzie Davidson's method with the following result: The depth from skin on back to the centre of tip of bullet was 2 inches, and centre of base of bullet $1\frac{1}{4}$ inches from surface. The bullet was easily extracted in the presence of the principal medical officer, who stated that the result was "highly satisfactory."

PLATE LX. (*a*).

Sergeant S., Lincolnshire Regiment, received a bullet-wound at inner part of left supra-orbital ridge. The projectile was supposed to be lodged at the back of the orbit, as the eyeball was protruding and the sight destroyed when studied closely. The skiagram shows outlines of the bones of upper part of face, including orbital cavity, as well as fleshy parts of forehead and nose, but no trace of bullet. The eyeball was enucleated a few days afterwards, but no foreign body was found.

Injury evidently produced by spent bullet, which drove a splinter of bone into the eye.

PLATE LX. (*b*).

Private L., Lincolnshire Regiment, bullet-wound left thigh. Front view shows bullet projecting from outer side of femur about the middle of the shaft. Side view reveals projectile lying parallel with shaft on upper side. The bullet was thus localized by these two photographs, and easily removed.

PLATE LXI. (*a*).

This shows the result of a bullet-wound of the left leg in a private of the Cameron Highlanders. The skiagram was taken some time after the injury, and shows clearly the fracture of both bones, the tibia especially being very severely damaged and suffering from necrosis. Several splashes of lead are also seen in the wound.

PLATE LXI. (*b*).

Private L., Seaforth Highlanders, bullet-wound left ankle. Front view showed bullet with broad end towards inner side. In the side view the bullet is seen in the joint between the astragalus and scaphoid. The bands of lead plaster are also visible. Incision over place indicated revealed bullet, which was readily extracted.

PLATE LXII. (*a*) AND (*b*).

Private H., Seaforth Highlanders, bullet-wound on inner side of right knee, over inner condyle of femur, about 2 inches from inner border of patella; knee-joint much swollen and inflamed.

Front view (*a*) revealed bullet in inner condyle of femur, long axis parallel to leg, lower end reaching to articular surface of condyle, upper end about two-thirds up condyle; bullet about ¼ of an inch from inner margin of condyle.

Side view (*b*) showed bullet about midway between anterior and posterior border of internal condyle of femur, lower end touching articular surface, and long axis nearly parallel to limb. The patella is widely separated from front of femur, and the front part of condyle appears to be much comminuted. Operation revealed bullet embedded in inner condyle, and was easily extracted.

I think the facts I have mentioned, together with the few cases I have shown you, must convince the most sceptical that the Roentgen rays are of the vastest importance and a great help to our diagnosis in military surgery.

I am convinced that the wounded soldier is often saved much mental worry and not unfrequently bodily pain by the help given to us by the X rays.

I have shown you how probing for an uncertain bullet, with its subsequent pain, is now a thing of the past in military surgery; how bullets can be localized with mathematical precision in the deeper parts of the body on field service; and also demonstrated the great help gained by aid of the rays in uncertain fractures.

THE ARCHIVES OF THE ROENTGEN RAY will, for the present, be published quarterly.

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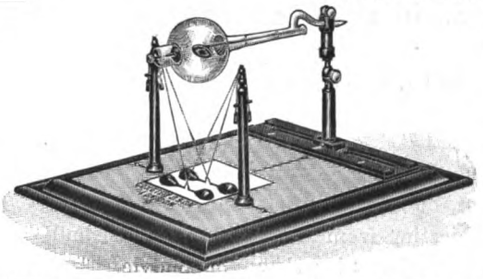

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ANOMALIES AND CURIOSITIES OF MEDICINE.

EDITED BY

GEORGE M. GOULD, A.M., M.D.,

ASSISTED BY

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An Encyclopædic Collection of Rare and Extraordinary Cases, and of the Most Striking Instances of Abnormality in all Branches of Medicine and Surgery, derived from an Exhaustive Research of Medical Literature from its Origin to the Present Day, Abstracted, Classified, Annotated, and Indexed.

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As a complete and authoritative BOOK OF REFERENCE, it will be of value not only to members of the medical profession, but to all persons interested in general scientific, sociologic, and medico-legal topics; in fact, the general interest of the subject and the dearth of any complete work upon it make this volume *one of the most important literary innovations of the day.* An especially valuable feature of the book consists of the *Indexing.* Beside a complete and comprehensive *General Index*, containing numerous cross-references to the subjects discussed, and the names of the authors of the more important reports, there is a convenient *Bibliographic Index* and a *Table of Contents.* The plan has been adopted of printing the *topical headings in bold-face type*, the reader being thereby enabled to tell at a glance the subject-matter of any particular paragraph or page.

"The practitioner who meets with an anomaly of any kind can, by reference to this work, readily discover whether similar cases have been recorded. The essential points of each case are given, and references are appended so that the subject can be followed up by those who wish for fuller information. The work may also on occasion afford help in prognosis by showing what extraordinary and extensive injuries have been recovered from. Again, it may be useful in medico-legal questions, as, for instance, with regard to anomalies of gestation; to malformations giving rise to uncertainty as to sex; to the viability of children, like Macduff, 'from their mother's womb untimely ripped'; to unusual forms of injury, self-mutilation, murder, and suicide; to simulation of diseases, malingering, and frauds of various kinds; and to feats of strength and endurance showing what the human body can be trained to do and to suffer. But, beyond the medical value of such a work, it has a wider scientific interest as revealing Nature in her workshop, moulding the clay which is to form the *divinæ particula æræi*, and her journeymen about her trying their hands at making men, and not making them well. It is of interest also to the student of human nature as throwing light on many curious points of character and disposition, the key to which is to be found in peculiarities of physical structure. Everyone, in short, who can say, with Terence, '*Homo sum, humani nil mi alienum puto*,' will find something to amuse if not to edify him in a work like the 'Curiosities of Medicine,' which deals with everything that most 'smells of mortality,' and which shows the human body in its strength and its weakness, and all the wonders of its structure and functions, and their excesses, defects, and perversions. Doctors Gould and Pyle have surveyed mankind from China to Peru, and have ransacked the literature of all ages and countries for records of marvels and monstrosities. It will be seen that in the compilation of a work so encyclopædic in character the authors have undertaken a veritable labour of Hercules. It is a guide to Nature's museum of teratology, a mine of interesting instances, ancient as well as modern, and a forest of references. So skilfully have the authors marshalled the vast mass of facts which they have collected, that the book can be read with pleasure as well as consulted with profit. The work of Doctors Gould and Pyle is, we venture to predict, destined to become A CLASSIC IN MEDICAL LITERATURE. As an unequalled collection of facts, clearly stated, lucidly grouped, and, last but not least, fully indexed, it will live while more scientific treatises become obsolete. It is only fair to add that the publisher has done his part of the work well. The print is clear, the illustrations admirably executed, and the book presents a handsome appearance."—*British Medical Journal.*

"Of especial value it must be to those interested in legal medicine, who, in giving expert testimony on questions whose solutions rest upon individual observations, can find just here the needed information."—*Vienna Clinical Weekly Review.*

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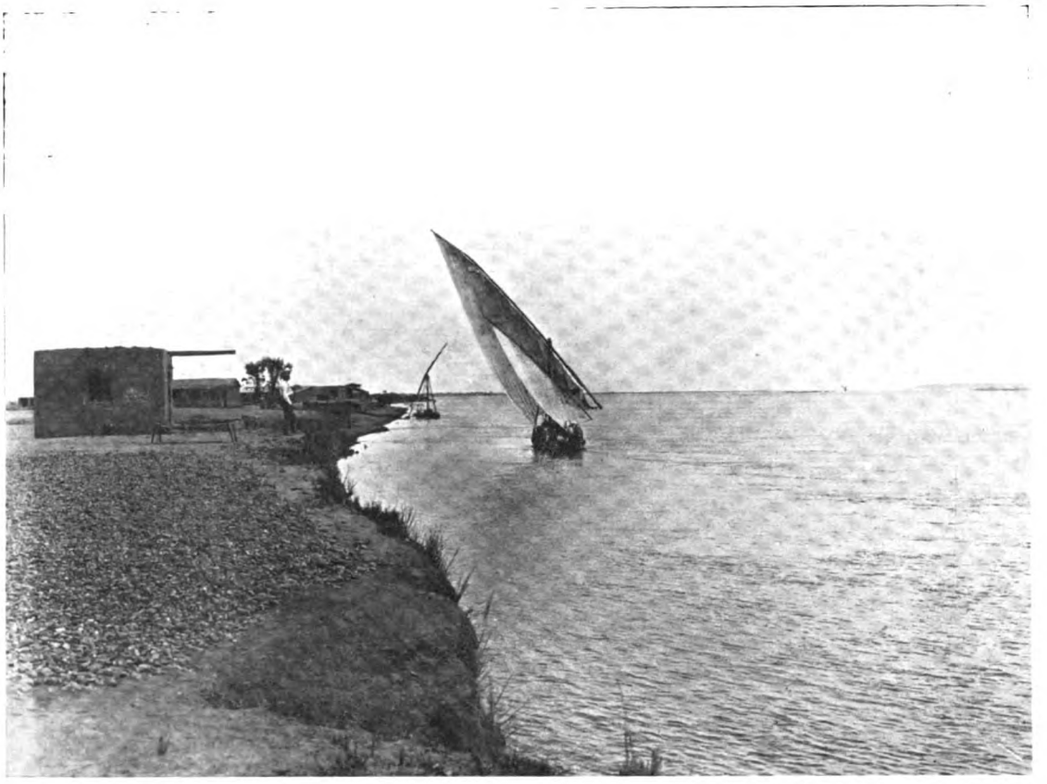
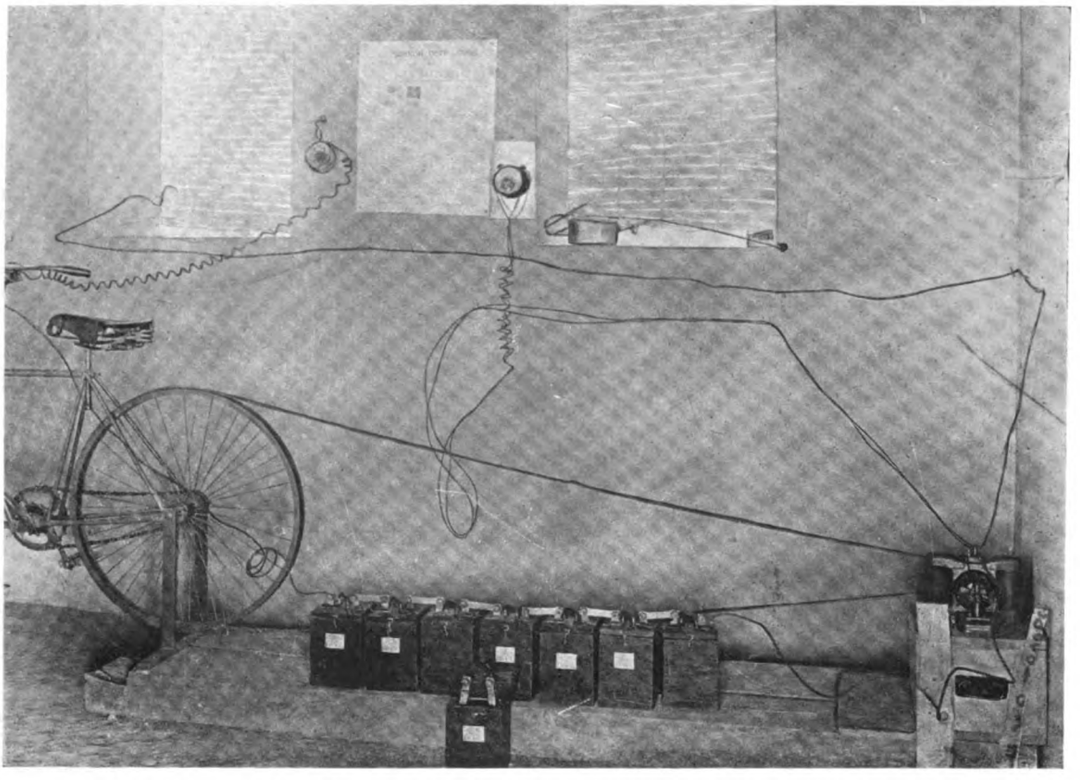


THE NILE AT ABADIEH.

Eight miles north of Berber, where advanced base Surgical Hospital was situated, and also headquarters of X Ray work.

PLATE LVII. (*a*).

(*"Archives of the Roentgen Ray." –Copyright.*)



METHOD BY WHICH ELECTRICITY WAS GENERATED FOR CHARGING STORAGE BATTERIES.

PLATE LVII. (*b*).

(*"Archives of the Roentgen Ray."—Copyright.*)

MAJOR BATTERSBY AND HIS ORDERLY TAKING A RADIOGRAPH.

PLATE LVIII. (*a*).

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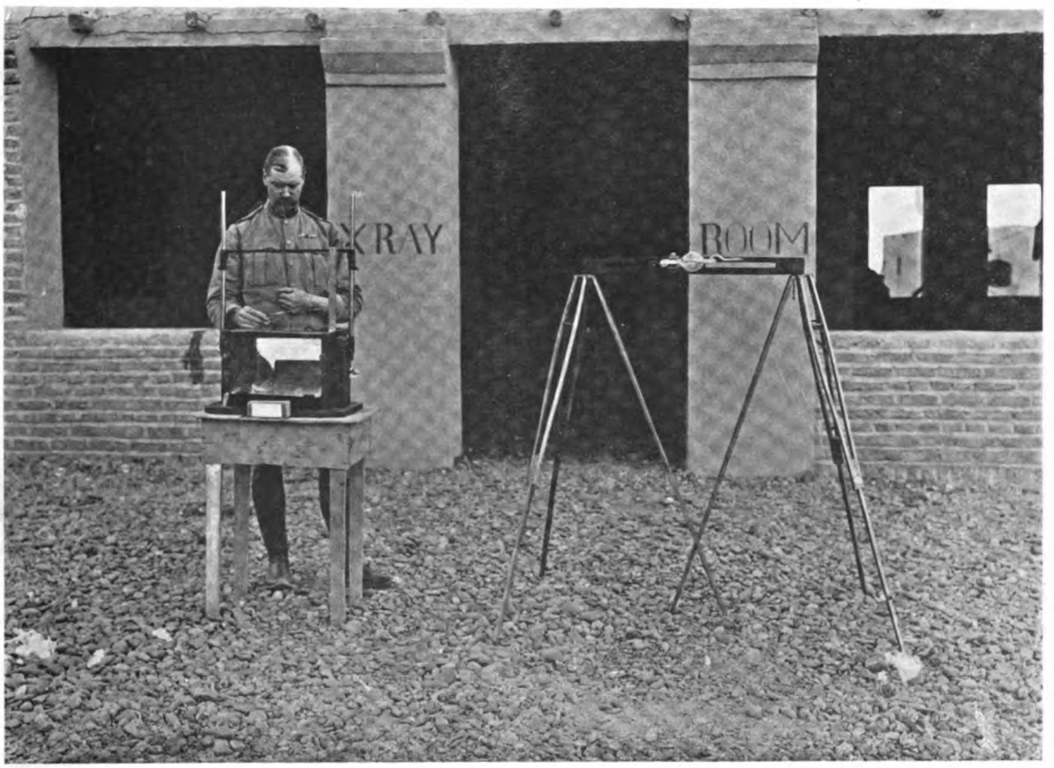


LOCALIZING APPARATUS.

PLATE LVIII. (*b*).

(*"Archives of the Roentgen Ray."—Copyright.*)

WOUNDS OF ARM, SHOWING FRAGMENTS OF BULLET.

PLATE LIX. (*a*).

("*Archives of the Roentgen Ray.*"—*Copyright.*)

BULLET IN RIGHT SHOULDER (TAKEN THROUGH DRESSINGS).

PLATE LIX. (*b*).

("*Archives of the Roentgen Ray.*"—*Copyright.*)

SPLINTER OF BONE IN EYE.

PLATE LX. (*a*).

(“*Archives of the Roentgen Ray.*”—*Copyright.*)

X

BULLET IN THIGH.

X SOUDAN DUST ON PLATE.

PLATE LX. (*b*).

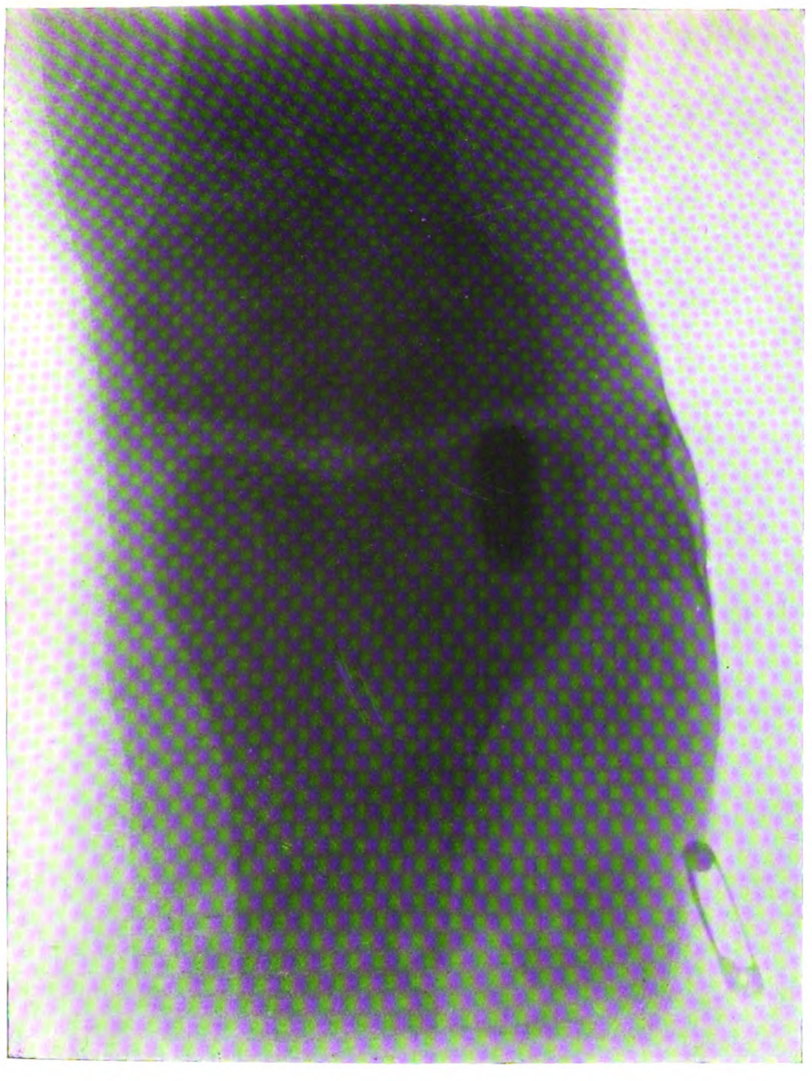
(“*Archives of the Roentgen Ray.*”—*Copyright.*)

FRACTURE OF BOTH BONES OF LEG BY A BULLET.

PLATE LXI. (*a*).
(*"Archives of the Roentgen Ray."—Copyright.*)

BULLET IN LEFT ANKLE.

PLATE LXI. (*b*)
(*"Archives of the Roentgen Ray."—Copyright.*)



BULLET IN KNEE (FRONT VIEW).

PLATE LXII. (*a*).

("*Archives of the Roentgen Ray.*"—*Copyright.*)

BULLET IN KNEE (SIDE VIEW).

PLATE LXII. (*b*).

("*Archives of the Roentgen Ray.*"—*Copyright.*)

VOL. III.—No. 4.] MAY, 1899

ARCHIVES

— OF —

THE ROENTGEN RAY

(*Formerly* ARCHIVES OF SKIAGRAPHY).

THE ONLY JOURNAL IN WHICH THE TRANSACTIONS OF THE ROENTGEN SOCIETY OF LONDON ARE OFFICIALLY REPORTED.

EDITED BY

THOMAS MOORE, F.R.C.S., AND ERNEST PAYNE, M.A. (CANTAB.),

Surgeon to the Miller Hospital. | *A.I.E.E.*

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A STONE IN THE RIGHT KIDNEY.

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AN EXOSTOSIS OF THE FEMUR.

A FRACTURE OF THE UPPER END OF THE HUMERUS WITH DISLOCATION.

A SUBLUXATION OF THE KNEE-JOINT.

VOL. III.—No. 4.] MAY, 1899. [PRICE 4/- *or* $1.

ARCHIVES OF THE ROENTGEN RAY.

EDITORIALS.

ALL available space was occupied in our last issue by the reports of the meetings of the Roentgen Society and Professor Roentgen's "Observations on the Properties of X Rays," so that we were unable to offer any remarks on the contents of the number.

The article by Professor Roentgen was taken from *Wiedeman's Annales*, and is probably known to most X ray workers. We thought, however, that a complete translation of this article—his third contribution to the Royal Prussian Academy of Sciences—would be of interest to our readers.

The record of Major Battersby's achievements with the X rays in the Soudan has attracted attention outside the immediate circles of those interested specially in radiography, and demonstrate conclusively the great utility of the X rays in warfare, proving the possibility of using them even on the battle-field.

The Wehnelt Interrupter is the latest novelty connected with X ray apparatus, and is exciting keen interest, not alone among those interested in practical radiography, but among scientists in general. Seventeen hundred interruptions per second, and the anode in a molten state! This is surely beyond the dreams of avarice.

Mechanical interrupters have been made to give a great number of makes and breaks, but generally at the expense of the current supplied. With the Wehnelt break, *and* with tubes that will stand the extra pressure, we ought to be able to show many things with ease that have been seen as yet only in exceptional cases.

It is to be hoped that the new interrupter will be shown working at the next meeting of the Roentgen Society. We give a short abstract of Dr. Wehnelt's paper in the *Electrotechnische Zeitschrift*, and also abstracts from various letters in the technical journals by Professor S. P. Thompson, Dr. Macintyre, Mr. W. E. Marchant, and others. Mr. Campbell Swinton brought the instrument before the Institution of Electrical Engineers and the Physical Society.

Practical workers are endeavouring to discover the best means of working the interrupter with more than one platinum anode, to avoid some of the effects of heating of the latter, and of devising the most suitable form of resistance, or possibly of impedance, for regulating the current.

The effects of impedance due to self-induction hinder the action of all transforming apparatus where alternating or intermittent currents are concerned. A certain amount of impedance appears to be necessary, however, to bring about the action of the Wehnelt interrupter. Without self-induction the current would become continuous, producing merely electrolysis of the liquid in the containing-vessel.

Considering the importance of the subject under discussion at the meeting of the Roentgen Society of February 7, it is unfortunate that more members were not present. The radiography of soft tissues covers a field that is of great interest to the surgeon and importance to the patient.

It is not merely greater power of penetration that is wanted on the part of the rays, but also greater discrimination. Most speakers agreed that a "soft" tube was necessary. The question also arises as to how far the rays are obstructed by the glass. We hear that good results have been obtained with a "tube made from glass containing lithium." Then, again, with regard to the way in which the tube is rendered "soft." Will a tube which has never been highly exhausted give the same results as one which has a high vacuum and is rendered "soft" at the time of working by the admission of a gas by artificial means? Dr. C. Lester Leonard speaks favourably of the latter form of tube in his remarks on the radiography of renal and other calculi,

which will be found in another column. The President mentioned a radiograph which showed the abdominal aorta in an adult; it would be interesting to know the exact history of the tube with which that radiograph was obtained.

At the Meeting of the Roentgen Society in March, an interesting paper was read by Dr. S. M. Lowe, of Lincoln, on "Practical Radiography in relation to Medicine and Surgery," wherein many useful hints were given applicable to everyday work with the X rays. It was illustrated by excellent radiographs of cases, and was followed by a lively discussion carried on by many members of the society.

Dr. Thurstan Holland's two cases of lupus before and after treatment with the X rays illustrate beautifully a new field for their usefulness, which was quite unexpected when Roentgen's discovery was first published to the world. We have heard of several cures of skin affections by the same means, but these are the first, we believe, of which illustrations have been published, in this country at all events.

The four cases of calculus—two in the kidney and two in the bladder—are of special interest. In each instance the diagnosis made by the ordinary surgical methods was confirmed by the screen and the radiograph. The diagnosis of stone in the kidney is easy enough in some cases, but in others it is extremely difficult; and the "new light" seems to be able to settle the difficulties in many instances, and to give valuable information in all. The process will be useful, we believe, not only to point out when there is a stone in the kidney, but also when there is not. We have ourselves examined several cases, with screen and radiograph, where a stone in the kidney was suspected, but none found, and the subsequent histories of the patients have, in each case, apparently confirmed the diagnosis made by means of the rays.

We give these specimens as excellent examples of what is being done in England and America by two of the best exponents of the radiographic art, and with the hope that they may contribute, if even in an infinitesimal way, to the *entente* between the two Anglo-Saxon nations.

The illustration of Mr. Jonathan Hutchinson junr.'s extraordinary case of exostosis of the femur is excellent, and does credit to the X ray department of the London Hospital, where it was produced.

The radiographs of a complicated injury to the shoulder by Mr. Wilson Noble, and of a subluxation of the knee-joint by Dr. Roome, are very interesting examples of unusual accidents.

Mr. Cookson's rabbit shows that this animal is a very good subject for the study of soft tissues by the aid of the X rays.

We regret that some radiographs which have been lithographed ready for publication have been crowded out of this number, but will appear in the next. Among them are a remarkable specimen of an "injected infant" by Mr. Glew.

THE ROENTGEN SOCIETY.

A MEETING of the Roentgen Society was held at 11, Chandos Street, Cavendish Square, on Tuesday, February 7th, 1899, Mr. C. MANSELL MOULLIN, M.D., F.R.C.S., President, in the chair.

Mr. WILSON NOBLE described a special form of Toepler air-pump, after which a discussion took place on the subject of the radiography of soft tissues, introduced by the President.

MODIFIED TOEPLER PUMP.

The objects aimed at in designing this pump were:

(*a*) That it should work automatically.

(*b*) That it should have no rubber tubing.

(*c*) That it should have no stopcocks.

(*d*) That air should never enter, even whilst tubes were being fixed for exhaustion.

(*e*) That the mercury should not come in contact with damp air or dust.

(*f*) That it should be of simple construction, and easily repaired by anyone with an elementary knowledge of glass-blowing.

(*g*) That it should not be liable to break.

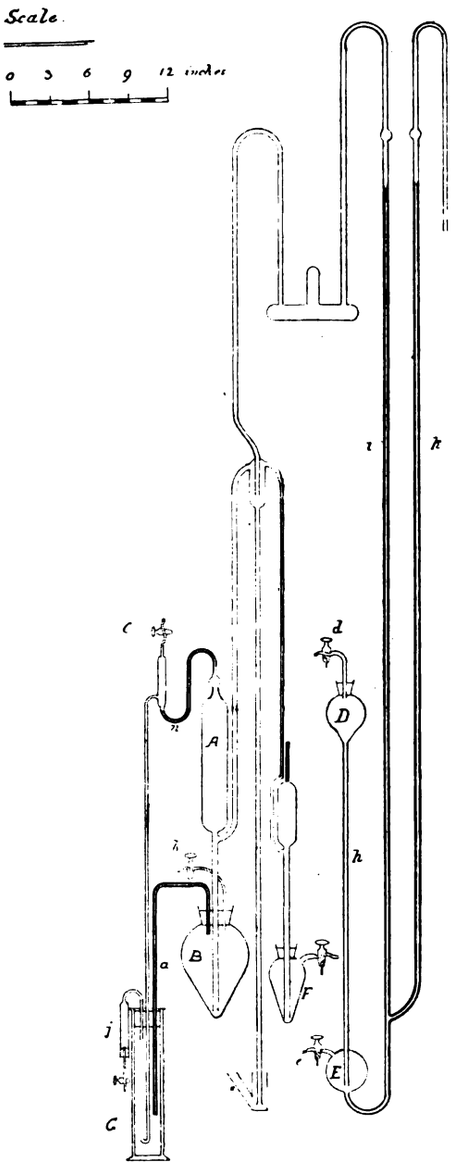
(*h*) That it should be capable of maintaining a high vacuum for a prolonged period. To secure this, most of the other conditions were necessary.

The first point, the pump being automatic, was briefly alluded to in describing a previous pump that I had made.*

All the stopcocks shown are connected with an ordinary filter-pump, and a partial permanent vacuum is maintained outside of them. *B* is the reservoir of mercury,

* See ARCHIVES, Vol. II., No. 4, p. 7.

and there is also some mercury at the bottom of *G*. Suppose the pump to be vacuous and air to have access to *B*, which will be the case if the mercury in *G* does not reach as high as the end of *a*, the mercury in *B* will rise in *A*, overflow through *n* and sprengel down the fall tube *c* being closed, and rise in *G* until it seals the end of *a*. When this happens, a vacuum will be created in *B*, and the mercury will descend in *A* and rise in *a*. By the time the mercury has fallen to the junction below *B*, enough will have been drawn up from *G* to unseal the end of *a*, when air will again enter *B*, forcing the mercury up into *A*. The only air with which the mercury can come in contact is dried and filtered in passing through *j*, and, as it passes through no india-rubber tubing, it remains clean for a considerable time. So far the pump is very similar to one that was made for Captain Thomson, which he was good enough to show me when I was having my first pump on this principle made. I am indebted to him for many valuable suggestions — amongst others, in part for the plan I have adopted for opening the end of the pump without admitting air or using a stopcock, and where my plan differs from his is in the fact that I have discarded india-rubber tubing while he has not.



This part of the pump consists of the bulbs *D* and *E*, which are connected with the filter-pump by the stopcocks *d* and *e*. These are 2-way Friedrich's stopcocks, and will allow the bulbs to be put into communication either with the vacuum or with the outside air, but outside air cannot pass into the filter vacuum. These are connected with the barometer tubes *i* and *k*. To make the arrangement work, *E* is filled with mercury, *e* is opened to the air, and *d* opened to the vacuum. When the mercury is drawn up into *D*, *e* is closed and *d* opened to the air. Mercury will fall in *h*, but not sufficiently to fill *E*, in consequence of the air that is there confined. If there is air in *i* and *k*, the mercury in these tubes will stand at the same height as it does in *h*; but, as a vacuum is produced in *i*, the mercury, of course, rises in *i* and falls in *k*. The tube to be exhausted is now sealed on to the end of *k*, and the T-piece by which this was done is attached to the filter-vacuum, and when the mercury in *i* and *k* are nearly level it is sealed off. *D* and *E* are now connected with the filter-vacuum by their respective stopcocks, and are closed as soon as the mercury has fallen to below the junction of *i* and *k*. The pump is now in working order.

When it becomes necessary to open *k* to attach a fresh tube, air is let in by *e*, and when the mercury has risen as far as it will in *D*, *e* is closed, and air is let in at *d*. Mercury will now stand about two-thirds up *h*, and the barometric height higher in *i* and *k*. *k* may now be opened, when mercury will fall in *k* and rise in *i*, but no air will pass by the junction of the two tubes.

The remainder of the pump, consisting of a McLeod gauge, a barometer tube for admitting air, and a drying bulb, requires no explanation.

DISCUSSION
ON THE RADIOGRAPHY OF SOFT TISSUES.

THE PRESIDENT said, my first duty, gentlemen, is to thank the Society for the honour they have done me in asking me to introduce this discussion. There is no

need to say anything about the importance of it. Those who know the value that Roentgen's discovery has been to surgeons, so far as the bones are concerned, will be able to form a very fair idea of the immense gain it would be if the soft tissues could be shown in a similar way. The heart and great vessels and the lungs have already been mapped out. Much, however, remains to be done in the region of the abdomen and for the muscles of the limbs. Occasionally, when least expected, an unusual degree of success has been met with. The abdominal aorta has been shown in front of the lumbar spine. The falx cerebri has been seen through the cranium, and the outlines of many muscles have been photographed with unmistakable clearness. The problem before the Society to-night is to suggest the way in which these effects can be obtained at will.

So far as I am aware, no attempt has ever been made to effect any changes in the absorptive capacity of the tissues. It is not probable that much can be done, but some effect may be produced by regulating the amount of circulating blood. The opacity of the bones is due to the salts of lime; that of the soft tissues, in some measure, to the iron contained in the myohæmatin and hæmoglobin. The former is fixed in amount, though it varies greatly in different muscles. The latter is constantly varying. A muscle may be taken either immediately after hard work, when it contains five or six times as much blood as when it is at rest, or in a state of absolute anæmia, by employing an elastic bandage. Such a difference in amount might reasonably produce a difference in absorption, and it is probably owing partly to this, partly to the width of intermuscular septa and the presence of fat in them, that muscles sometimes stand out with exceptional clearness.

Much more is to be hoped from manipulation of the tube. Everyone is agreed that the quantity of light as distinguished from its penetrative power is most important. It would be especially useful if those present to-night would be so good as to give some estimate of the ampèrage they use. It seems to me that there is a distinct tendency to raise the number of ampères employed. Certainly heavy discharges seem to give the best result.

What, however, would be especially valuable would be an expression of opinion on the part of this Society as to the relative merits, so far as the soft tissues are concerned, of a hard tube with a high potential and short exposure, giving so much less chance of flickering of light, or of movement on the part of the object, and of a soft tube with a comparatively low potential and longer exposure. The part of the body must of course be taken into consideration. The penetrative power of a soft tube is rarely sufficient for the trunk.

It would be interesting to know whether anyone has tried varying the degree of penetration during exposure, either by shifting the cathode or by interposing thicker or thinner screens of metal, such as sheet iron, to cut off a certain number of the rays. It has been suggested, but I am not aware of any practical result having been obtained.

Finally, there is the further question whether some better method of developing and printing cannot be evolved. At present there can be no doubt that the negative shows a great deal more detail than the print. If this could be increased in some way, and transferred, the value of radiography, so far as the soft tissues are concerned, would be immensely enhanced.

Mr. Wilson Noble said that he could only offer the results of his own experience with different apparatus. He had obtained the best results with soft tubes. The distance of the tube from the plate had to be considered; the tube should be as far away as possible when the part to be radiographed was some way from the plate, otherwise only those objects near the surface next to the plate were given with any definition. If the details of the spine only were wanted, the tube might be nearer, so that the sternum would be ignored.

With regard to the effects of secondary rays given off by the air, which had been discovered by Professor Roentgen, there seemed to be less of these with "soft" than with "hard" tubes. It was difficult to decide the question, What was a soft tube? The blue cloud sometimes seen in a tube was undesirable, and tubes showing this phenomenon were not of much use. In exhausting a tube, it was best to rather prolong the process than otherwise.

Mr. E. Payne said that there seemed to be some special power of discrimination in the rays given out by a new tube, which went away after it had been used a few times. He found it best, therefore, when taking a radiograph where soft tissues were concerned, to use as new a tube as possible. With reference to the variation of the vacuum during an exposure, this might be tried with the Queen tube, which had an arrangement for lowering the vacuum by admitting a gas into the bulb.

Mr. Campbell Swinton thought that an old tube

ought to work quite as well as a new one. While the tube was in action, the cathode appeared to get rid of the gas that was in it, and it took time for the gas to get back again.

Mr. WEBSTER said he had obtained the best results in connection with soft tissues when working the tube with a red-hot anode and using a large current.

Mr. VEZEY said his experience as to quantity of current hardly agreed with that of the previous speaker; he had obtained good results with a current of not more than 3 ampères.

Dr. WALSH observed that from its density and simplicity of shape the shadow of a bone was recognisable, however faint and enlarged; not so with muscles, which were of varied pattern and threw hopelessly vague shadows when near the tube. He had recently obtained a photograph of a tumour of the kidney in a stout woman; the diagnosis was made independently, but the radiograph showed that the liver was not involved. In bones, the best detail was obtained when they were near the plate, much more so in soft tissues, which were so readily blotted out by the rays. For future advances, we should probably have to look to a great extent to photography, but in any case it was difficult to read the photographic record of soft tissues.

Dr. G. M. LOWE described some experiments in the radiography of birds and other small animals; he had obtained the best results with the tube at a comparatively long distance from the plate, and with a rather long exposure.

Major BEEVOR, R.A.M.C., said, with reference to some cases in the recent Frontier War in India, that when a man had been undergoing great exertion, and was brought in wounded and perspiring, the penetration of the rays was very much delayed. He recollected two cases where men were wounded in the thigh, one by a fragment of telegraph wire and the other by a soft bullet. The muscles seemed to be so opaque to the rays that it was diffiicult to obtain any radiograph at the time. The man wounded by the fragment of telegraph wire had had a hard hand-to-hand fight with the enemy, and in this case he was not able to localize the piece of wire immediately, even when using a 10-inch spark. A day or two afterwards a radiograph was obtained showing a fracture of the femur, with a large splinter of bone torn from one side.

THE ROENTGEN SOCIETY.

A MEETING of the Roentgen Society was held at 11, Chandos Street, Cavendish Square, on Tuesday, March 7th, 1899, Mr. THOMAS MOORE, F.R.C.S., Treasurer, in the chair.

The following were elected members of the society, Major Battersby, R.A.M.C.; Major Beevor, R.A.M.C.; W. D. Jefferson, L.R.C.P., Ripon; Robert Jones, F.R.C.S., Liverpool; A. W. Wigmore, L.R.C.P., 39, Compayne Gardens, N.W.

Mr. F. W. GLEW showed an interesting radiograph of a nine-months fœtus, the arteries of which had been injected with mercury.

Mr. VEZEY announced that he had been deputed by the Council to arrange with Mr. Apps for the exhibition of Dr. Wehnelt's new contact-breaker, but was sorry that he had not been able to do so, as a continuous current was required for working the contact-breaker, and the supply in Chandos Street was on the alternating system.

Mr. WEBSTER showed a radiograph of a fracture of the neck of the femur, on which osteotomy had been performed by Mr. Poland in the Miller Hospital. The result of the operation, which was very successful, was plainly shown; the upper parts of the two femurs together with the bones of the pelvis were clearly seen. The patient was an adult. Mr. Webster also showed a radiograph of an aneurism of the brachial artery at the elbow.

Dr. G. M. LOWE, of Lincoln, then read a paper on practical radiography in relation to Medicine and Surgery, illustrated by numerous radiographs, which was followed by a discussion.

PRACTICAL RADIOGRAPHY IN RELATION TO MEDICINE AND SURGERY.

By G. M. LOWE, M.D., F.R.C.P. Edin., Lincoln.

I DEFINE radiography as the art of obtaining an image or representation of a substance by means of certain *transmitted* actinic rays acting on sensitized films or papers.

In ordinary photography the image is produced on the sensitized surface by the action of solar actinic rays *reflected* from the object.

Radiography somewhat resembles photomicrography,

where actinic rays from the sun or from artificial light are transmitted through thin sections of substances, or partially transparent objects, and affect the chemical constituents of the negative plate.

In passing through various substances, X ray vibrations appear to be absorbed or arrested by metals and metallic compounds, according to their density or atomicity.

Thus, whilst those vibrations pass readily through a moderate thickness of flesh, they pass less readily through deeper and more vascular parts, and still less through bone; so that, if all the conditions are perfect, and a correct exposure has been made, all the fine gradations of light and shade should be shown in the radiograph as in the photograph.

For medical and surgical purposes, radiographic pictures must be clear and well defined; the parts must be in due proportion, and the point of view correctly chosen.

To obtain these results, the operator must use an efficient apparatus, and possess a thorough knowledge of the technique of the subject.

Commencing, as many of us did, early in 1896, with the comparatively poor appliances available at that time, it is remarkable how much good work was done. Since then radiographers have kept a keen watch upon the researches of the physicist, and the best instrument-makers of the day have devoted their talents to the wants of both.

In bringing together these three classes of workers, as in this evening's meeting, and thus enabling them to interchange ideas, the Roentgen Society is doing good work, and fully justifies its existence.

In this sense, therefore, though only a humble worker in an ambitious field, and under the disadvantage of living at a considerable distance from London, the mere description of my small experience may provoke useful discussion among the members present, and thus lead to further enlightenment.

I now use one of the Electrical Power Storage Company's 6-cell accumulators, with a capacity of 50 ampère hours, and place in circuit a rheostat having a total resistance of 1 ohm, by which the current is adjusted to an average of from 6 to 8 ampères, according to the resistance of the tube and other conditions. I always use the *minimum* current which effects my purpose, frequently testing, during the operation, the X ray output with the screen, and placing the tube at as great a distance from the plate as will ensure a correct image of the part under examination.

My coil is one, made by Watson and Son, capable of giving a 12-inch spark. It is furnished with a "Vril" contact-breaker, which works satisfactorily and is easily regulated.

Judging from my own experience, I think the nearer the tube, and the greater the intensity of the current, the greater the loss of detail. In the case of the hand and arm, from 12 to 40 inches, and the same for the foot and leg, give the best results.

On the other hand, of course, increased distance means a considerably increased exposure—a matter of importance only in the case of nervous patients and children. For the thorax or pelvis, I place the tube from 24 to 30 inches distant from the plate, according to the size and condition of the patient; for the head and face, 20 inches from the plate.

The length of exposure varies, as is well known, with the blood-supply of the subject, the plethoric or full-blooded being very opaque, and the pale or anæmic being comparatively transparent. The exposure necessary may be judged with some exactitude by the use of the screen, in the same way as the focus-plate is used in photomicrography.

I have always preferred the Cadett lightning plate for negatives, but have recently used the Lumière special X ray plates with marked success. The only drawback in the working of the latter is the length of time required for their development.

A large sheet of plate glass is a useful adjunct both for the couch and table, as it lessens the risk of breaking the negative, and also to some extent insulates the parts.

Watson's penetrator focus-tube is a most reliable piece of apparatus. It is not given to sparking, is always cool, and has a long life. I used one of these tubes almost daily from April 1 last to the end of November. A tube kindly selected and sent me by Mr. Cossor, although very lively, has turned out some excellent work.

I have used Watson's "Vril" contact-breaker ever since its introduction. It gives no trouble, and works smoothly; but there is at times more sparking between the platinum points than is pleasant for screen-work, though this may possibly be due to faulty adjustment on my part.

The apparatus as a whole is fairly portable, and can

be taken to a patient's house and set going without much trouble.

In narrating cases, I shall confine myself to those that have an especial interest to the radiographer.

Hip-joint Disease.—Three cases of supposed *morbus coxarius* have been examined. Only one had any disease. Of the others (one was a girl aged fourteen, and the other a boy of twelve), both had the contracted heel and pointed toe; both used the regulation crutch and boot, and were supposed to be lame for life; relieved of appliances, both now run to school without the slightest limp. Such are examples of the cases that build up the reputation of the advertising quack, and explain where the crutches which ornament the entrance-halls of electro and hydropathic establishments and the rocks at the Grotto of Lourdes come from.

No. 1.—I call your especial attention to a radiograph of a fractured femur. The patient, a young girl, fell, and whilst on the ground another person fell across her thigh. The fracture was carefully treated; the outer contour of the thigh and leg was normal, the usual landmarks and length indicating perfect apposition. The lower fragment is at an angle to the axis of the femur, and the joint therefore is out of truth. The radiograph was taken at the patient's house.

No. 2.—The shoulder and portion of the thorax which I now exhibit is that of a patient who was recommended to the Ventnor Hospital for Consumption, and sent to me as the local referee for that establishment. I found no physical signs to account for a frequent irritable cough, and as I always examine every available thorax for possible tubercle (ancient or modern), I submitted this case to the same process. The result, as you will see, indicates no disease of the lung, but a clavicle separated from its acromial attachment, and a consequent dropping of the shoulder. This case will be sutured with wire, and I hope to exhibit the result at a future meeting of this Society.

No. 3.—I exhibit, as a contrast to No. 2, an excellent radiograph of a normal shoulder.

No. 4 is the thorax of a tuberculous patient who had formerly suffered from Graves' disease. The well-defined dark spot seen in the radiograph at the apex of the left lung is indicated in this patient on percussion by a dull area, much greater in extent, with considerable surface tenderness.

No. 5 is a fracture of the tibia from a direct blow. The patient had travelled to me from a considerable distance, and the leg was much swollen and tender. The radiograph indicated the position and character of the fractured ends, and greatly facilitated their correct co-aptation.

No. 6 is the partial fracture of a tibia of a man aged thirty-five years. The fracture extends horizontally half through the shaft of the bone, and then vertically upwards, the upper portion springing forwards exactly like the break in a Malacca cane. The man was a confirmed drunkard, and this accounts for the fuzzy condition of the radiograph.

No. 7.—The hand of a soldier who had fractured the metacarpal bone of the forefinger whilst striking a man with his closed fist.

No. 8.—A curiously V-shaped fracture of the second finger, becoming impacted by muscular contraction.

No. 9.—Hand showing two sesamoid bones of the thumb.

No. 10.—Foot not only showing a needle with remarkably good definition close to the bone, but also curious bony excrescences from the distal phalanges.

No. 11.—An arm showing considerable injury about the elbow, and also fracture of the radius and ulna, without displacement.

No. 12.—The arm of a girl with supposed fracture of the radius, to illustrate definition of bone with well-marked indication of tendons about the elbow, the tube being placed at a distance of 45 inches.

No. 13 is the head of a sporting dog, showing considerable minute detail.

No. 14 represents the forearm of a soldier with fracture of the radius, taken in two positions. The radiograph is poor, owing to the restlessness of the subject, but illustrates in a forcible manner the necessity of examining a fracture from more than one point of view. This was taken five weeks after the injury.

Nos. 15 *and* 16.—Some years since I ventured to suggest in the pages of *Nature* that it would save surgeons and others both time and expense if a paper could be made sufficiently sensitive to yield the image direct from the object, instead of going through the tedious process of developing and fixing (and then printing from) glass negatives, which subsequently have no further use. Several papers were offered, the best of which are Eastman's Bromide and the Nikko-sensitive papers. Three or more of these can be used at once with quite satisfactory results for hands and arms, but they are of no use for the deeper tissues.

The examples produced represent an elegant hand, and one deformed by rheumatoid arthritis.

Although I can obtain with the apparatus I have described a fairly good representation of the parts in and about the pelvis, I must confess I am not satisfied with the results; in thin persons and in children the radiographs are clear and well defined, but in stouter subjects the diagnostic value of the prints is often poor. Judging by the progress already made, I think that we shall not have long to wait for the means to overcome this difficulty.

I have not experienced any cases of dermatitis from the action of the X rays in my own practice, but I lately had the opportunity of examining a lad who was suffering from the effects of this accident. In his case a prolonged exposure had been made for hip-joint disease, with the tube almost touching the skin in the groin: dermatitis occurred a few days afterwards, followed by sloughing of the skin. When I saw the case, there was an ulcer of the indolent type, with sharp edges and white inert surface about the size of a five-shilling piece in the groin; there was a marked absence of pain and soreness in the part. After resisting every form of treatment, the ulcer got suddenly well about four months from its commencement.

With considerable diffidence, but with the distinct object of provoking discussion, I should like to suggest that these lesions are due to the direct de-electrification of the parts by the X rays.

Lord Kelvin points out that X rays will, like the flame of the spirit-lamp, de-electrify solid bodies such as a bar of iron charged with positive or with negative electricity —easily if exposed to the air, but with greater difficulty when insulated by paraffin.

In making a prolonged application of the continuous current, if the moistened electrodes are kept on one part of the skin too long, a redness, followed by a vesicular rash, shows itself at both points of contact, but with greater intensity at the negative pole. The best described cases of X ray dermatitis show that eruptions follow prolonged exposures when the tube is placed very near the skin, and that the subsequent conditions are due probably to injury to the trophic or nutrient nerves of the part.

In one case, mentioned, I believe, by Dr. Walsh, a somewhat similar eruption occurred on the opposite side of the body.

The magnetic condition of the tube in operation is well known, for although carefully polished, it soon becomes thickly coated with dust, which on examination is found to consist of metallic particles.

It is conceivable, therefore, that an outward rush of an electro-magnetic current from a small area of skin surface, corresponding in size to the adjacent tube-bulb would, if prolonged, cause certain electrolytic effects which would induce dermatitis. In the instance of an injury to the opposite side of the body, it is only necessary to assume the accidental presence of a nail or other conducting point on the table on which the patient rested acting as a feeder from the earth current.

Mr. MOORE, in opening the discussion, regretted the absence of the President, who had attended the Council meeting, but owing to a severe cold, accompanied with hoarseness, was unable to speak. He thanked Dr. Lowe for his interesting paper, and especially for his remarks on the practical application of the rays. It was quite necessary in many cases of fracture to take radiographs from more than one "point of view," and he mentioned a case which occurred lately in his own practice of a fractured tibia, where a side-view showed scarcely any displacement, but a front-view taken subsequently revealed very serious displacement, which could only be remedied by screwing the broken ends together. He decidedly agreed with Dr. Lowe's opinion, that "the Society was doing good work in bringing makers and workers together," as the medical members doing practical radiography often obtained valuable information from the physicists and makers of apparatus at the meetings.

Mr. PHILLIPS was unable to agree with Dr. Lowe's theory as to the production of focus-tube dermatitis. It had been suggested that the rays from the tube de-electrify that part of the patient's body upon which they strike, and that, in general, the patient may always be considered as electro-negative to the charge upon the focus-tube itself. Under the conditions of practical radiography, however, it was difficult to arrive very exactly at the electrical condition of the patient, who may be assumed to be partially connected with earth while, at the same time, subjected to the sudden induced changes of potential difference between the *unscreened* leading wires in connection with the terminals of the tube.

In the experiments carried out by Lord Kelvin upon the de-electrifying property of the rays, the results of which were referred to by Dr. Lowe in support of his

theory, the greatest care was taken to screen off all electrostatic effects due to the coil and the leading wires, as well as from the charges upon the walls of the focus-tube itself. With regard to the actual effects, in some cases, of X rays upon the skin, it is curious to notice that while many experimenters speak of the production of a horny layer, Mr. Hyndman, in his book on "Radiation," points out that G. Brandes has found X rays soften the dry skin of a mummy.

Mr. WEBSTER said, with reference to Dr. Lowe's theory of dermatitis, that he obtained the same effects on his own skin from the brush discharge as those attributed to the X rays, as he had mentioned on a previous occasion.

He had experimented by using plates of glass and metal placed immediately under the photographic plate, when taking hands with a second's exposure, and found that a better result was obtained with glass than with the metal plates or with wood. Was it due to the insulating properties of the glass or reflection of small per cent. of rays? There was often considerable electrification of the objects near the coil, and also of those away from it. When working in wet weather he found that the walls and door furniture of the room became charged, and people entering had received shocks from the handle of the door, which was of metal, about 10 feet away from the coil, a large one giving an 18-inch spark, but used for a working tube with from 2 to 5 inches.

With reference to obtaining impressions of the muscles he found they would show more clearly when in tension than when at rest.

With regard to the tubes, they seemed to puncture at the end of the small projecting portion where they were sealed off. He had found that the best details were obtained with hard tubes, the anode being red-hot, with a white-hot spot in the centre. He used an E.M.F. of 24 volts, so that the hammer vibrated at a high speed, giving a deep musical note, and when the tube was working properly there was infinitesimal sparking at the platinum contacts.

As to fluorescent screens, there appeared to be one particular size of crystal which was more efficient than any others; this was also the opinion expressed by Professor Hodgkinson, of Woolwich.

Mr. VEZEY, like the chairman, was glad that Dr. Lowe had accentuated the value of the society in bringing together different workers. The radiographer brought his results to the Society, and asked the physicists and manufacturers how they could be improved upon. Referring to the possibilities of greater results being obtained with the new Wehnelt contact-breaker, he said that the current was so strong that ordinary tubes were easily perforated, and a stronger form of tube would have to be made to work in connection with it; the makers must set to work and produce stronger tubes that would resist the extra strain.

Dr. NEWMAN asked Dr. Lowe for more accurate details as to length of exposure and distance of tube from the objects. In his own note-books he found conflicting details on these points. There was certainly an advantage in having the radiograph as near the natural size as possible, which was obtained by having the tube a comparatively long way off.

Dr. WALSH said that the case of dermatitis occurring on both sides of the body, referred to by Dr. Lowe, was that published by Dr. Reed; since then Dr. Macgilloray had described another where both sides of the head were affected. With regard to Dr. Lowe's theory of de-electrification, the hair might have some effect in aiding this, but any explanation that might be put forward must also account for the selection of the hairs.

Dr. F. H. Low, London, said he thought that full-blooded patients were more opaque than others, and he agreed with Dr. Lowe's and Mr. Webster's remarks that muscles in tension came out more clearly in a radiograph. It seemed to be settled that old tubes were quite as good as new ones, and he believed it would soon be demonstrated that a 6-inch coil would do all that one wanted.

Mr. E. PAYNE referred to his experiments in connection with the dermatitis question, and regretted that the coming number of "THE ARCHIVES" had been unavoidably delayed, which contained the report of the discussion. His experiments seemed to show that anything placed near the tube, including the patient, might become electrified, and that the discharge of this might possibly have some effect, especially if the insulating properties of the skin were temporarily modified by the effect of the X rays. The question as to how the patient was insulated would also affect this result. If the patient were well earthed, with his feet on the floor, it would be difficult to charge him in any way; if he were reclining, on the other hand, on a couch, the legs of which were of dry, well-varnished wood, he might be sufficiently well insulated to receive a charge. The difficulty in accepting this as a complete explanation lay in the

results produced where electrification was prevented by the use of an earthed metal screen, as in the experiments described by Professor Elihu Thomson in *The American X Ray Journal.*

Mr. GAIRDNER said, with reference to Mr. Webster's remarks on the puncture of the tube at the end, this was probably due to the great heat produced by the electric bombardment. He did not think there was any advantage in the piece of shellac that some makers had tried as a protection. With regard to Dr. F. H. Low's theory as to the size of coils, he thought the tendency was to use larger ones.

Dr. LOWE made some remarks in reply.

In our issue of November, 1898, the name of Dr. Mansel, Ashtead, Surrey, was incorrectly given among the new members of the Roentgen Society. It should read Edward L. Mansel.

THE INFLUENCE MACHINE IN X RAY WORK.

By HEBER ROBARTS, M.D. (Editor "American X Ray Journal").

(Abstract of a Lecture delivered at the National College of Electro-therapeutics.)

AFTER drawing attention to the importance of a good knowledge of the uses of the influence machine in connection with electro-therapeutic work, the lecturer went on to describe the construction and management of the machine and other apparatus required for practical radiography. The room in which the apparatus is set up should be large and dry and free from furniture. The machine should be in a case which is as nearly as possible air-tight. The axles should be ball-bearing and the doors fastened with screws. Place in porcelain dishes 10 lb. of granular calcium chloride previously baked in an open oven or dried on a stove; cover with cheese-cloth the entire contents and the dish, and place in the case; close the case absolutely tight. Should the generating output of the machine at any time become lessened, the calcium can be removed from the case and dried again and returned to the case.

It is never necessary to use Leyden jars. In the inferior machines, in order to get the best effect, the positive pole may be interrupted by attaching the conducting wire to an independent stand, with the end of the wire separated from the positive pole of the machine about an inch. With regard to the size and number of the plates, a two-plate machine is not calculated to do X ray work; it will be found disappointing. "A four-plate machine should never be attempted for anything more than examination of the extremities. A six-plate will give good views of the trunk if the plates are 30 inches in diameter. An eight-plate will give excellent views of the hip, the heart can be seen 15 feet away, and any portion of the body can be radiographed." For examinations with the fluorescent screen, "a machine of ten plates of 30 inches in diameter will give a good view of the heart 15 or 20 feet away from the tube; the bones of the hand can be seen 50 feet away; the head of the femur in a heavy man can be seen instantly 4 to 6 feet distant. The softer structures are studied. Some of the larger vessels are traced, and all the glandular organs come into plain view and their denser portions are studied. Pathological changes, assuming the conditions of hypertrophy, atrophy, induration, softening, abscesses, whether in the brain or trunk, can be seen."

A tube which fails to work can be restored to usefulness by reversing the discharge through it. Additional assistance is offered when the Morrell interrupter can be used. In most instances five to fifteen minutes will restore a tube that has been worked out. A tube which has too great resistance may be restored by interrupting the negative discharge while properly connected.

THE WEHNELT INTERRUPTER.

By Dr. A. WEHNELT.

(Abstract of Article in the "Electrotechnische Zeitschrift," January 26, 1899.)

IF a current is sent through an electrolyte by means of two electrodes of unequal surface, the current does not remain continuous, but becomes rapidly intermittent. The phenomena connected with this have been investigated by Davy, Planté, Lagrange, Hoho, and others, and a welding and hardening process has been founded on them by Lagrange and Hoho.

Experiments were carried out to determine whether the current merely varied between two limits, or whether there was a complete interruption. If the break were complete, it ought to work in circuit with an induction-

coil like any other contact-breaker. In the experiments a glass beaker was used containing dilute sulphuric acid, into which were introduced a large lead plate and a platinum wire sealed into the end of a glass tube, so that only a small portion might project into the acid; contact was made with the wire leading to the coil by filling up the glass tube with mercury. At first the current was sent through the beaker, entering by the lead plate and leaving by the platinum wire, as in the welding apparatus of Lagrange and Hoho; the wire soon melted, and the current was tried in the opposite direction, with a surprising result. A stream of sparks was set up as soon as the current was turned on. With the first experiments 120 volts was used, but it was found that with the reversed direction of the current the E.M.F. might be reduced to 80 or 90 volts. Further experiments showed that the interruption would even begin to take place with 12 volts. By using sufficient E.M.F. a flaming arc could be produced, with a note indicating about 1,000 vibrations per second. The break is so complete and instantaneous that the condenser becomes superfluous.

Self-induction, which has hitherto been reduced wherever possible, is no drawback to the efficient working of this interrupter, but, if anything, assists the action. A higher E.M.F. seems necessary if there is no self-induction in the primary circuit.

The interruptions increase in number with the increase of the voltage. With the apparatus employed for the experiments 12 volts was the lowest E.M.F. with which the action could be produced. Dilute sulphuric acid of 20° to 25° B. was found most advantageous. For the cathode any metal may be employed; for the anode (the active electrode) platinum was found to be the best.

The frequency of the interruptions was found to be from 200 to 1,700 per second, the higher rates being determined by comparing the sound emitted by the discharge with that given by tuning-forks.

The current strength increases with the surface of the active electrode, and can be regulated by changing the latter without the introduction of resistance, which absorbs energy. The number of interruptions diminishes with the increase of the current, as the apparent resistance of the coil increases.

If an incandescent lamp, of higher voltage than that of the battery, is placed across the terminals in parallel with the primary coil, it lights up brilliantly.

This interrupter is very suitable for all experiments with discharges *in vacuo*, and especially for working X ray tubes. The current is very steady, which is a great advantage when making screen observations. The full power of the coil can be used, so that a tube intended for a 30 cm. spark can be worked on a coil giving a nominal spark of 15 cm.

The interrupter can also be used to advantage in connection with Tesla coils and wireless telegraphy.

THE WEHNELT INTERRUPTER.

Professor S. P. Thompson, in a letter to the *Electrician*, March 17, p. 731, describes the results of some experiments carried out with the assistance of Mr. J. D. Coales and Mr. W. R. Dawson.

The phenomenon is essentially one of resonance, and depends upon (1) the presence of self-induction in the circuit, (2) the operation of the small platinum anode in the acid as a capacity. The flow of current from this anode, when a continuous current is applied, is unstable since the evolution of gas on its limited surface checks the flow until the accumulating gas is bodily removed from the surface. Given this initial instability, given the well-known fact that a polarisable platinum anode has a capacity, and given that self-induction is present, there at once follows by electric resonance an oscillatory current superposed upon the continuous current, the period of the oscillations depending, as is well known, on the product of the self-induction and the capacity. The frequency of the discharge can be varied, both by varying the size of the anode and by altering the self-induction by introducing into the circuit a choking-coil with a movable core.

Professor J. A. Fleming, in the same Journal, recommends also the use of a choking-coil of low resistance, in addition to a non-inductive resistance, for purposes of regulation. "If a couple of Leyden jars are connected in the usual way across the secondary terminals of the coil, the discharge is quite startling." The positive electrode is best made by passing a copper wire down a porcelain tube, with a platinum tip welded to the wire, and passing out through an ebonite plug.

At a meeting of the Physical Society, on March 10, the Wehnelt current-interrupter was exhibited and described Mr. A. A. Campbell Swinton.

The instrument exhibited by Mr. Swinton consisted of a glass cell with a cylindrical negative electrode of lead,

and platinum wire as the positive pole, with a solution of sulphuric acid 1 part and water 5 parts. As the self-induction of the circuit is diminished the spark-pitch rises; it becomes infinite when the self-induction vanishes, the break therefore will not work in a circuit having no self-induction. The minimum E.M.F. at which the instrument shown would work was 25 volts. The platinum wire must be in the solution before the current is turned on; it would not work if dipped into the solution while in circuit. After a time the instrument "fatigues" and will not work, the platinum becoming red hot. It is supposed that the oxygen generated at the platinum electrode forms a more or less insulating film which interrupts the current until absorbed by the surrounding water.

For Roentgen ray work the apparatus was most effective, but the heating effect was so great that the cathodes of the focus-tubes were soon melted.

The PRESIDENT (Professor Oliver Lodge) said he was rather surprised that the self-induction of the primary coil was not sufficient of itself to form the induction factor in the impedance necessary for perfect working. Did reversal of the current assist the recovery from the "fatigued" condition of the apparatus?

Professor MINCHIN said the apparatus would be more useful if a lower E.M.F. could be used. He had succeeded in working the break with 12, but not with 10 volts. He found that a mechanical tap to the base of the apparatus restored the working condition when it was "fatigued," which seemed to show that this was due to the presence of gas around the electrodes.

There appeared to be a definite depth of immersion of the platinum wire at which the apparatus worked with minimum current.

Mr. APPLEYARD suggested that the liquid immediately around the submerged part of the wire was in the spheroidal state, which would introduce a further cause of electrical separation between wire and liquid.

Mr. BLAKESLEY agreed with the suggestion of the President, that the instrument possessed capacity, which was shown by the rise of potential at the terminals.

Mr. MORRIS described experiments made with a Wehnelt interrupter and incandescent lamps, as mentioned in Dr. Wehnelt's article. He found that "fatigue" was remedied by reversing the current.

At a meeting of the Institution of Electrical Engineers on March 9, Mr. Swinton exhibited a Wehnelt current-interrupter. In a discussion which followed, Professor Silvanus P. Thompson said there was clearly something in the nature of resonance taking place. It had long been common knowledge that the deposit of gas upon an electrode had the effect of making that electrode act, to a certain extent, as a capacity. He referred also to the researches of C. Varley and Professor Sloughinoff.

Dr. Macintyre, in a letter to the editor of *Nature* (March 9, 1899, p. 438), points out some facts connected with the practical working of the Wehnelt contact-breaker in connection with radiography. Variations are obtained by the number of active electrodes; by modifying these we can vary the length of the spark, also its frequency and thickness. Large and small Crookes' tubes were excited from a coil, capable of giving a 28-inch spark, with perfect safety. Photographs were obtained with much shorter exposures, and deep-seated structures examined more easily, by the greater brilliance and steadiness of the fluorescent screen.

Mr. R. J. Strutt (*Nature*, March 30, p. 510) draws attention to the following extract from the proceedings of the Royal Society (vol. xxv., p. 549), where an apparatus very similar to the Wehnelt interrupter is described by Spottiswoode:

"Another form of contact-breaker was also occasionally used. The principle upon which it was based was the sudden interruption of a thin film of connecting liquid by a discharge between the electrodes of a circuit. The mode of effecting this was to make one electrode terminate in a platinum plate fixed in a horizontal position, and supplied with a uniform film of dilute sulphuric acid; the other in a platinum point, the distance of which from the plate is capable of delicate adjustment by means of a screw. Electro-motive force required for this break is not less than that of five cells of Grove. As soon as the current passes, the fluid between the plate and point will be decomposed and electrical continuity broken. This done, the fluid flows back again and continuity is restored. By the proper adjustment of the supply of fluid and of the distance between the electrodes (the latter varying from ·05 to ·001 of an inch), the number of disruptions may be made to attain 1,000 per second. The current delivered by this form of break is exceedingly uniform, and the effects produced are

quite equal in delicacy to those produced by the electro-magnetic or by the wheel break."

In the same number of *Nature*, p. 510, Mr. William Webster states that he used an interrupter similar to that of Wehnelt in 1874, with fifty Grove cells. His attention to the phenomenon was due to the accidental short-circuiting of electrodes during electrolytic experiments; he found that the old masters of electrics had used it before. He always worked the ordinary break of his coil with such rapid vibrations that a musical note was produced, and with only an infinitesimal amount of sparking, this result being obtained by heating the tube with a spirit-lamp.

M. D'Arsonval (*Comptes Rendus*, February 27) gives the following explanation of the action of this interrupter. The current makes the platinum point white-hot; a layer of non-conducting vapour forms round the platinum, which interrupts the current. Then the vapour condenses, the current is re-established, and the process repeats itself.

Mr. E. W. Marchant, writing from the Blytheswood Laboratory, Renfrew (*Electrician*, April 7, p. 841), describes a multipolar form of Wehnelt interrupter. The cathode consists of a lead box containing the fluid, the anode of six platinum wires (18 mils diameter) fitted into an ebonite plug at the end of a glass tube and soldered to a copper wire, thus avoiding the mercury connection of the first pattern. The "fatigue" appears to be due to heating; with a considerable resistance in series, it was possible to stop the intermittent discharge by increasing the number of anodes, *i.e.*, by increasing the capacity, which helps to confirm Professor S. P. Thompson's theory of resonance.

In the same journal Mr. E. E. Brooks says that the interrupter can be worked with an alternating current if a tube of suitable length and exhaustion is used. "The discharge is oscillatory on closed circuit, but with an air-spark of suitable length it can be made more and more unidirectional until, with exact adjustment, it becomes apparently entirely so. The arrangement promises to be a great boon to workers who have only access to alternating current mains."

FLUORESCENT SCREENS.

THE fluorescent screen is by no means the least important part of the apparatus necessary for X ray work. Its use ought to quite supersede the old and barbarous but aforetime absolutely necessary practice of diagnosing fractures of the bones by obtaining crepitus, *i.e.*, by rubbing the two broken ends of a bone forcibly together. By its aid, also, it can be ascertained whether a fractured limb, after it has been set, is in proper position, and whether a dislocated joint has been properly reduced; and the condition of the heart and other internal organs can, in certain cases, be ascertained. A good screen is, therefore, an essential, and we regret to think that there are many inferior ones offered for sale.

The subjoined account of Mr. Gotz's fluorescent screen was written by one of our most esteemed contributors, Dr. Norris Wolfenden, and forwarded to us, by the late editor, six months ago. It was so eulogistic that, although we had the greatest confidence in the knowledge and discretion of its writer, we hesitated to endorse it until we were able to verify the account for ourselves.

We have had two of these screens in regular work for the last four months—one a large one, which will show the whole of the trunk of an adult body, and the other smaller.

During that time we have given them a thoroughly good trial, and have submitted them to other experts, and we can endorse Dr. Wolfenden's opinion. Knowing, moreover, that screens are said to deteriorate if not frequently exposed to light, we have kept these in a dark room, except when they were being used, and have not found any falling off in their brilliancy.

Notes by Dr. Norris Wolfenden.

"The barium platinocyanide fluorescent screens, submitted to us by Mr. Gotz, are, under his direction, manufactured by Messrs. Johnson, Matthey and Co., of Hatton Garden, who are also the makers of the salt. We have given them an extended trial, and desire to say of them that they are the very best fluorescent screens, of this salt, we have yet seen. The salt is emulsified with a special collodion mixture. The previously prepared screen is coated over twice, or even three times, with the salt, a special paper having been found by several experiments to be the best.

"These screens are coated by hand; indeed, contrary

to an opinion sometimes held, no good screen can be coated by machinery.

"The result is as near perfection as possible, and we believe that those who will give them a trial will be surprised with their great excellence and exceptional brilliancy."

Extracts from Medical and Scientific Journals.

Surgery in the Græco-Turkish War.

THE LANCET.

In the numbers for January 14 and 21, 1899, is a long and interesting article on "Surgery in the Greco-Turkish War," by Mr. Francis C. Abbott, M.S., F.R.C.S. The writer sums up as follows:

1. The Roentgen rays should always, if possible, be available at that hospital nearest the front in which the wounds can be first properly examined and dealt with.

2. The electricity should be derived from a secondary battery consisting of separate covered cells, charged from the nearest, a man-of-war or other steamer, or by means of a cycle motor, as has been recently done in the Soudan by Major Battersby, R.A.M.C.

3. Skiagrams should be taken on to Eastman's positive paper, which is sufficiently satisfactory for the detection of foreign bodies.

4. The apparatus is of no use on the field, where the detection of bullets can only be an incentive to premature exploration.

5. The less wounds are tampered with before satisfactory surroundings are reached the better. All difficult bullets should be removed by a fresh incision and the track ignored.

6. The modern bullet, from its greater penetrating power, will be much less frequently found in the body than its predecessors. It is practically aseptic, and there is no urgency for removal.

7. The hole of entrance is often extremely small. Suppuration is generally due to pieces of clothes carried into the tissues. Superficial septic sinuses should be excised. Wounds of lungs by modern bullets run a comparatively favourable course.

8. Small-bore bullets may bore through a bone without causing any line of fracture whatever, and every degree of injury, from this up to the most extensive comminution, may be met with.

9. Passive movements and massage, when possible, should be begun early in bullet-wound fractures.

False Teeth Swallowed.

January 24.—A note by Dr. J. S. Sharman on a case in which three false teeth, attached to a gold plate, were swallowed by a patient, but could not be seen on the fluorescing screen, although the patient's body was thin and was readily penetrated by the light. The plate was presumably covered by the ilium and so obscured from view.

Stereoscopic Photography and Skiagraphy.

THE BRITISH MEDICAL JOURNAL.

In the number for December 3, 1898, is a communication from Mr. Jas. Mackenzie Davidson, M.B., F.R.C.S., entitled "Remarks on the Value of Stereoscopic Photography and Skiagraphy: Records of Clinical and Pathological Appearances, with Stereoscopic Illustrations."

This is a most interesting and useful article, as it gives a full account of all the apparatus and methods required for stereoscopic radiography.

The writer says:

"The advantages of stereoscopic photography for the purpose of recording and illustrating medical and scientific work is very great. For years past I have used it with the greatest benefit to myself and to students. Once its advantages over the ordinary single picture are realized, it appears certain that many illustrations in medical journals and in scientific or other periodicals—even in books—will be produced stereoscopically.

"The observer will be able to use some simple form of stereoscope (similar to a pair of pince-nez) for examining the illustration, and will at once see it in perfect relief.

"It is only necessary to look at two good stereoscopic skiagraphs, in a Wheatstone's stereoscope, to realize at once how thoroughly practical and important this method is in surgical work.

"A single skiagraph is often confusing, if not misleading, but with two, properly taken and viewed in a stereoscope, the picture stands out in true relief, and shows clearly the relation of the parts."

The apparatus is made by Messrs. Muirhead and Co., Elmer's End. The Wheatstone stereoscope is made by Messrs. Currey and Paxton, Great Portland Street, W. Wheatstone's papers on the subject, and Leconté's "Sight," both of which are useful for reference, may be found in the "International Science Series," Kegan Paul and Co.

In the same number is "A Case of Bullet Wound of the Leg, in which the Bullet was located by Stereoscopic Skiagraphy, illustrated"; by Mr. Howard Marsh, F.R.C.S.

The Application of X Rays to the Examination of Fuels.*

IRON AND COAL TRADES REVIEW, *February* 24, 1899.

The constituents of mineral fuels present considerable differences of transparency to the X rays, and, while carbon offers no hindrance to their passage, silica, silicates, and pyrites, amongst other minerals present, act as opaque bodies.

M. H. Couriot, Professor at the École Centrale, Paris, recently directed attention to these facts in a communication made to the Académie des Sciences on the radioscopic examination of combustible minerals, in which he pointed out that such an examination reveals instantly the presence of foreign matter—the slightest trace of silica, or the smallest fragment of schist, invisible to the naked eye, appearing on the screen either in the form of a dark stain or an opaque band across the otherwise transparent and illuminated area; the passage of coal, from the state of greatest purity, through a series of intermediate stages, until, becoming gradually more and more impure, it resolves itself into little more than an impregnated clay, being clearly defined, and serving as an indication of the purity, or otherwise, of the material under examination.

With the object of arriving at practical results derived from such examination, the author repeated the experiments of M. Couriot, and submitted to the action of the X rays a certain number of samples of coal, coke, conglomerates, and oolite coal.†

The present experiments were effected by means of a coil with a $\frac{3}{8}$-inch spark, furnished with a commutator and a Villard core, the duration of the exposure being one minute. The samples did not as a general rule exceed $\frac{3}{8}$ inch in thickness.

The first thing noticeable was the difference in the effects obtained from the same samples when presented in varying planes to the action of the rays. When the rays passed in a direction perpendicular to the axis of stratification an infiltration of silicate of extreme attenuity sufficed to arrest their passage, so that while on one hand an obscured field failed to indicate the degree of impurity of the specimen, a clear one sufficed to prove its absolute purity. If, on the contrary, the sample was placed so that the rays should be parallel to the plane of stratification, the purely carboniferous portions were defined with great clearness on the screen or upon the radiograph, while silicates and pyrites appeared as opaque markings disseminated throughout the material. Unless, also, the greatest care is exercised that the times of exposure are identical, the radiographic results are no longer trustworthy. Another important factor is the relative thickness of the samples to be examined, for, other things equal, a thin section is more easily permeable by the rays than is a thick one, and inequality between the samples will also be a source of error unless allowed for. The most satisfactory results were obtained when the passage of the rays was normal to the cleavage, and a preliminary examination on the screen should always precede and serve as a guide to the best means for obtaining subsequently a permanent radiograph. In a number of cases radioscopic examination furnishes better indications as to the composition of the fuel than radiography, with the additional advantage of being far easier to carry out, and requiring less skill on the part of the operator.

In order to determine the percentage of ash present in ground samples of fuel, the following method was devised: A quantity of pure coal dust of known ash having been obtained, a series of standards, the ash of which increased in increments of 10 per cent., were prepared by the addition of the necessary quantities of powdered shale. These standards were placed in cubes made of chemically pure paper, the iron and other foreign ingredients rendering ordinary paper unsuitable. These cubes measured approximately $\frac{7}{8}$ square inch. The result of these preparations was a graduated series of radiographed shades, which could serve as a basis for a rough comparison with unknown samples treated similarly.

Upon a similar principal M. Couriot has devised a very ingenious piece of apparatus by means of which the amount of foreign matter present can be determined within 0·005. The complete details have not yet been made public, but the following description will suffice to describe its nature: A box, presumably of celluloid, is employed. The box possesses the shape of a right-angled wedge, *i.e.*, it has two parallel sides, a base, and two sides starting from the base and tapering to form an angle. This angle is chosen so that the increment of thickness of the wedge is conformable to a scale placed along that plane which is at a right angle to the base, this plane being moreover the radioscopic screen of the appliance. The box is filled with the samples of coal to be examined, and on exposure to the rays a point can be found at which transparency ceases. This point is determined by means of a fine steel wire which slides vertically across the screen. The rays pass through the narrow portion of the wedge, but at some distance above the acute angle they become interrupted, the proportion of foreign matter present being sufficient to create opacity. At this point the steel wire ceases to be visible, and the position it occupies against the scale mentioned above at the time of its disappearance serves to indicate the percentage of impurity in the sample experimented on.

The applications of such a system of examination are endless. Not only coal and coke, but tar, anthracite, electric arc carbons, ozokerite, asphalte, and graphite, even when enclosed in pencils, can be tested by these means, while they also serve to indicate approximately the carbon contents of a number of explosive substances, such as gunpowder and nitro-cellulose.

*Specially adapted from a memoir by J. Daniel in the Belgian *Annales des Mines*.

† By this is probably meant certain mineral deposits similar to the bituminous shale of North Yorkshire and parts of Scotland. Such deposits occupy the position of the ordinary oolite, and contain sandstone, shale, and carbonaceous matter intermingled. The Brora seam, formerly worked by the Dukes of Sutherland, was of this nature.—*Note by Translator.*

Testing Gold Quartz by the Roentgen Rays.

MACHINERY, *Johannesburg*, *February* 1, 1899.

An ingenious application of the Roentgen rays has recently been made, viz., to ascertain the presence of gold particles in quartz. The particles of gold in a paying gold quartz are often so finely divided as to be invisible to the naked eye. Since gold is much more opaque to the Roentgen rays than quartz, it is natural to suppose that some indication of the presence of gold in quartz would be given on the screen or the photographic plate when the quartz is traversed by the Roentgen rays. A physician in Los Angelos, California, is reported, on accidentally photographing a lump of gold quartz, to have found on the shadow of the outline of the quartz a number of very dark points. These

points were due to the presence of particles of gold in the quartz. It is possible, therefore, to detect the presence of gold in quartz by the Roentgen rays, and it may sometimes be convenient in the laboratory, but it is not to be expected that the gold prospector will add a battery, an induction coil, and vacuum tubes to his kit.

Printing by X Rays.

DAILY NEWS, *March* 9, 1899.

The discovery of a method of applying the Roentgen rays to printing was recently announced from America, but the inventor's promise to produce five million copies of a newspaper by a single process did not inspire confidence. M. Izambard, a French inventor, claims to have discovered a process which, while being considerably more modest in its pretensions, renders both typographical composition and printing machines unnecessary. It consists of exposing the original, either hand or type-written, to the X rays, over a block of sensitive paper, the original being in a special ink, impermeable to the rays. Thousands of sheets, it is stated, may be penetrated and impressed simultaneously with the characters of the original in a few minutes, or even, if necessary, in a few seconds. There are processes which simplify the development and fixing, and others which enable both sides of a sheet to be printed at once. The inventor believes that by his method newspapers will be produced with ten times the present speed, with a much smaller staff, and with a greatly reduced cost on account of material. For the present, however, the more intimate details of the revolutionary discovery are the secret of the patent offices.

MANCHESTER COURIER, *March* 11, 1899.

A new terror will be added to life if the latest rumour concerning the Roentgen rays is verified. To sit in one's flesh and photograph one's bones is an advance which the creator of Frankenstein might have envied. But a French inventor has a project in view which, if successful, should not only revolutionize printing, but bring about a revolution. He promises to produce five million copies of a newspaper by a single process, which is to do away with typographical composition and printing machines. The Macaulay or Dickens of the future, or, for that matter, the journalistic George Washington of any description, will simply take his original manuscript, hand or type-written, to the Aldus or Elzevir of his particular department in Grub Street, who will expose it to the X rays, over a block of sensitive paper, the original being in a special ink, impermeable to the rays. It is said that thousands of sheets can be penetrated and impressed simultaneously, in a few seconds, with the characters of the original. American scientists have already been attracted to this field by the possibilities of the Roentgen rays, but have retired baffled. But M. Izambard, the French inventor, promises to be the Columbus of the discovery. He claims that both sides of a sheet may be printed at once, that newspapers will be issued at ten times their present speed, with a smaller staff and reduced cost of material. If the invention should unhappily be confirmed, the Peace Conference will doubtless unanimously condemn the method, as outside the pale of honourable usage. In the meantime we may breathe freely, for the French submarine boat and the Manchester sewage problems are yet unsolved, and a feeling of pity for his brother man may induce M. Izambard to allow the century to die quietly.

An Action for Damages caused by X Rays.

BRITISH MEDICAL JOURNAL, *April* 8, 1899.

An action has recently been brought in a Paris law court for damages caused by the X rays. Mme. Mockert suffered from an affection of the hip-joint. Her medical attendant recommended an operation; the patient disliked the idea. In order to ascertain that it was necessary, an examination with the X rays was made by a specialist. The first sitting lasted forty minutes, the second forty-five, the third an hour and a quarter. The result was negative. After the second sitting the skin of the region radiographed was red and mottled. A few days subsequently there was a sore place, which was followed by a scab. The suffering was so intense that it was feared that the patient would go out of her mind. Gangrene seemed to be threatening. Mme. Mockert was taken to the seaside. Five medical men attended her at a cost of £136 15s. Mme. Mockert and her husband sued the radiographer for £200 damages. Counsel for the defence read a letter from Dr. Bardet, head of the Laboratory of the Pitié Hospital, wherein he states that if any responsibility is attached to the use of Roentgen rays they cannot be utilized. The susceptibility of patients to the influence of the X rays varies like their susceptibility to that of drugs. The Court has decreed that a medical commission be appointed to decide as to the duration of the examination considered safe. Judgment is postponed.

The Danger of the Roentgen Rays.

DAILY NEWS, *May* 1, 1899.

CHICAGO, *April* 28.—The ex-patient of the Roentgen Rays Laboratory here who claimed 25,000 dollars compensation for alleged permanent injuries sustained by his treatment there, has been awarded 10,000 dollars. The plaintiff's case was that he sought relief from stiffness of the leg, but the application of the rays resulted in his having to undergo three amputations, besides suffering injury to his sight and hearing.—*Laffan.*

An Exploring Radioscope.

ELECTRICIAN, *April* 21, 1899.

In surgical radiography the orientation of a foreign body is not definite unless it happens to be situated in the perpendicular from the radiant point on to the sensitive plate. It thus may happen that an operation is made in the wrong place. To avoid this danger, A. Londe has designed what he calls an exploring radioscope. It consists of two rings, one of which is placed above and the other below the body to be examined. The axes of the two rings are made to coincide. An X ray tube will give shadows of both rings, but these shadows will not be concentric unless the radiant point also lies in the common axis. When this is secured the whole apparatus is shifted until the foreign body appears in the centre of the rings on the screen. Points are then marked on the skin at the centre of each ring, and the operator is then sure that the foreign body must be situated somewhere on the line joining the two points. It remains to

find whereabouts on that line it is. To do this the X ray tube is shifted aside a little, thus throwing the foreign body out of the centre. The subject is then removed, and a transparent scale inserted in the axis of the rings. That scale will cast a shadow, somewhere on which the foreign body appears. The scale reading against it marks the depth below the skin.—Londe, *Comptes Rendus*, March 27, 1899.

Properties of Uranium Rays.

ELECTRICIAN, *April* 14, 1899.

H. Becquerel has repeated some of his earlier experiments on the rays named after him, and has found that the conclusions originally derived from them were to a great extent erroneous. As a matter of fact, it cannot be proved that these rays, whether proceeding from uranium, thorium, polonium, or radium, undergo either polarization, refraction, or regular reflection. The absence of these properties places them on a line with Roentgen rays. There are some distinct indications of diffused reflection, and there again the analogy with X rays holds good. As regards absorption, it is found that polonium gives out rays which are easily absorbed, even by black paper, whereas radium and uranium rays have much greater penetrative power. As regards the source of the energy of these rays, the author still considers that an open question. Even when kept beyond the reach of any known radiation for three years, these substances still give out rays capable of impressing a photographic plate and of ionizing the air. It has been suggested that they undergo some internal process which leads to the radiation of energy, and as the latter is very small, such radiation could be kept up for very long periods. But that is unlikely, since no known physical process is capable of increasing the energy thus given out.—Becquerel, *Comptes Rendus*, March 27, 1899.

The Roentgen Rays in Spain.

BRITISH MEDICAL JOURNAL, *March* 11, 1899.

A laboratory for the application of the Roentgen rays was opened in Madrid under the name of Instituto Radiografico de España on February 20. The institute, the installation and equipment of which are on a magnificent scale, is said to have cost some two million pesetas (£80,000). We gather from the *Siglo Medico* that the impression produced by the size of the place, the luxurious manner in which it is fitted up, and the wealth of apparatus which it contains, on the large assembly of medical men and journalists who were present at the opening, was one akin to stupefaction. The director of the Institute is Dr. Mezquita. In view of the statements that have appeared as to the grave financial position of Spain, one can hardly help wondering where the large sum of money mentioned above was obtained; but however it may have been got, it must be admitted that it has been applied for a useful purpose. If money on a proportionate scale is forthcoming for medical institutions generally, Spain, even if she dies politically, according to Lord Salisbury's cheerful prognosis, has a vigorous scientific life before her.

The Seehear.

ENGINEER, *March* 10, 1899.

The latest development in Roentgen radiography is said to be an apparatus called a "seehear," a device by which a person may observe the action of his own heart, says a New York electrical contemporary. The "seehear" is a combination of a fluorescent screen with a stethoscope.

Blind to Roentgen Rays.

BRITISH COLONIAL DRUGGIST, *March* 31, 1899.

It has been computed that one person in every 800 is blind to the X rays; that is to say, when looking through the fluoriscope, they are utterly unable to observe the bones of the body, coins, or any other object which is clearly distinguishable by the ordinary observer.—*Medical Review of Reviews.*

A New Use for Electric Vehicles.

SHEFFIELD WEEKLY TELEGRAPH, *April* 15, 1899.

A case was reported recently of a clever application of the electric storage battery of an automobile, described as follows: A woman had received a complicated fracture of her arm, too complex for the physician to accurately locate. He then decided to make use of a Roentgen ray apparatus for this purpose, but found the patient too weak to be removed. He obtained the apparatus, but, having no source of electricity convenient to operate it, called an electric cab by telephone. The current from the battery in the cab was conducted to the apparatus by special wires, which successfully operated it and enabled the physician, by the usual observations, to locate the fracture in the arm and set the latter quickly.

It is said improvements are to be introduced in these vehicles whereby they can be made immediately serviceable to doctors in emergency cases.

An Appreciation of the "Archives of the Roentgen Ray."

ELECTRICITY, *February*, 1899.

The February number of this quarterly contains a deal of interesting matter. The first paper, by Mr. E. Payne, M.A., dealing principally with dermatitis (burns), produced by exposure to the rays from a live tube, is indicative of the scientific mind, for it is obviously written with much thought. The concluding assertion, with its qualification, is worth noting: "We may," says Mr. Payne, "safely assert that the length of exposure necessary to produce any injury is at least three or four times that required to obtain a radiograph with the improved apparatus now at our disposal." Dr. Walsh follows with a much longer paper on the same subject. This is also good, but, unfortunately, the writer has to some extent spoilt himself at the conclusion by "summing up," as he terms it, and this summing up is merely a rather pompously-worded statement of four self-evident facts. But perhaps the feature of greatest interest is Major Battersby's paper concerning the work which he did recently on behalf of our wounded soldiers in the Soudan. Despite the difficulties under which he and his assistant laboured, the gallant Major has a fine collection of radiographs to show, and many of these are beautifully reproduced in this number. Further, there are discussions on these three papers, and two abstracts, also, curiously enough, dealing with Roentgen ray burns. There is also a translation of Professor Roentgen's lengthy communication to the Prussian Academy of Science. The Professor describes very many

interesting experiments, giving careful details of the apparatus used. We make no particular mention of any of these experiments, or deductions therefrom, because *anyone really interested in radiography cannot afford to be without this issue of the "Archives."*

A New Electrical Theory.

REVIEW OF REVIEWS, *February* 15, 1899.

Professor John Trowbridge, of Harvard University, writes in the January *Forum* on the upper regions of the air, and unfolds a theory which he states accounts for the phenomena of the Northern Lights, thunderstorms, and the magnetism of the air. As we receive all our energy from the sun, he infers that the electrical storms and magnetism of the earth result from the action of the sun—not through direct magnetic induction, but through the short waves of energy active in producing electrical and magnetic effects in the upper regions of the air:

"It has been discovered independently by two observers—M. Perrin, a Frenchman, and H. Winkleman, a German—that the X rays have the property of communicating an electric charge to conductors. If, therefore, X rays reach the earth from the sun, they are competent to give an electrical charge to our atmosphere. The side, therefore, of the earth turned toward the sun would receive a charge in the upper good-conducting regions of the air. The charge would tend to dissipation, and there would be a flow of electricity toward the side of the earth not turned to the sun. The rotation of the earth on its axis from west to east would bring forward at each revolution fresh regions of the upper air to receive the electrical charging from the sun. There would be an accumulation of electricity on one side of the earth, and a diminution of electricity on the other. The conditions of the equalization of the electrical charge or the flow of electricity might be determined by the direction of rotation of the earth. If this flow took place from east to west, just opposite to the direction of rotation of the earth, and were sufficiently powerful, it would produce the magnetic north and south poles. . . . The electrical storms in the lower regions of the atmosphere might then result from the disturbance of the extent of the charge in the upper regions by means of great commotions in the air, which constitutes a vast atmospheric sea. This great region has its storms as well as the oceans of water. The Northern Lights may be due to a dissipation of a portion of the electrical charge through layers of rarefied and good-conducting air, and thunderstorms can be looked upon as local descent of high electrical conditions prevailing in the upper regions of the air."

It is the bearing of his theory on the earth's magnetism that most interests the writer:

"The distance between the magnetic poles of the earth is a strong argument in favour of the theory that they are produced by electrical currents circulating about the earth. Such currents, competent to produce the poles of the earth, have not been discovered in or on the earth. If they exist, they may circulate in the upper regions of the air. The theory promulgated above supposes that they result from the conversion of the shortest waves of light into electricity, and that the flow of electrical currents is brought about by the rotation of the earth. This theory demands a high state of electrification of the upper regions of the air, and great electrical conductibility in these regions. The phenomenon of thunderstorms is an evidence of the former, and the increased conductibility of rarefied air, up to a certain limit, can be abundantly shown."

The Professor finds the comprehensiveness of his theory peculiarly fascinating to him.

*** *The Editors beg to thank those correspondents who have been so kind as to send them articles and prints of radiographs for the* ARCHIVES.

They would be very much obliged if contributors would send, with any prints intended for publication, a short account of the case by the medical attendant, and also an account of the process used in radiography—such as the voltage, ampèrage and spark employed, time of exposure, kind of sensitive plate or film used, or any other facts of interest.

Description of Plates.

PLATE LXIII. (*a*).

LUPUS OF THE FACE BEFORE TREATMENT.

PLATE LXIII. (*b*).

LUPUS OF THE FACE AFTER TREATMENT.

PLATE LXIV. (*a*).

LUPUS OF THE FOOT BEFORE TREATMENT.

PLATE LXIV. (*b*).

LUPUS OF THE FOOT AFTER TREATMENT.

TREATMENT OF LUPUS BY ROENTGEN RAYS.

By C. THURSTAN HOLLAND, M.D., Honorary Medical Officer in charge of X Ray Department, Royal Southern Hospital, Liverpool.

(*Paper read before the Roentgen Society, December* 10, 1898.)

SINCE June 1, 1896, to the present date, I have taken 725 radiographs, the plates of which I have kept. In addition, there have been a number of unsuccessful exposures, and a very large amount of screen work.

Further, I have superintended the X ray work for a friend of mine for more than one year, his apparatus being in daily use both for screen and plate work. The coils used have been Aps Newton, giving a 3-inch, 6-inch, and 10-inch spark. Tubes: chiefly those supplied by Newton, but in addition Watson's penetrator, Cossor's, the Zennder tube, and latterly a large one obtained for me by Mr. Isenthal. The exposures have varied from a few seconds up to an hour; several abdominal and hip cases, all long exposures, were within a short space of time exposed three or four times. The tubes have been placed at distances varying from 4 inches to 12 or 14 from the skin, worked in the early days without allowing the platinum to get hot, but during the past year also never, with Newton's tubes, without the platinum being absolutely red hot and kept so. The apparatus used has been the simplest—an accumulator, a coil, and tube. No attempt in any case at any protection; no special care in insulation of wires, etc.

With all this somewhat extensive experience, I have never seen the slightest damage of any kind, not even the removal of a single hair, nor the appearance of the slightest redness of the skin. But that the X rays (or something coming from the apparatus) have some effects upon the skin and other tissues I have certain evidence to prove, and this I propose to bring under your notice.

In April of this year (1898), hearing of lupus having been successfully treated by these means, I borrowed two cases from friends, to see what could be done.

Case 1.—That of a girl, M. R. (Photograph No. 1, which was taken in April, 1898, presenting, as you will see, a chronic, irregular, punched-out, tubercular ulceration of the foot, which had lasted for eleven years). It was at that time very painful, and discharging freely, and almost incapacitated the girl from walking. Varieties of treatment, scraping, the application of caustics, etc., had been unsuccessfully tried. All treatment except the use of boracic ointment was stopped, and between April 18 and June 14, 1898, the foot was exposed to X rays nineteen times. A Newton tube was used except on two occasions. The glass of the tube was placed a distance of 4 or 5 inches from the skin, the platinum was kept red hot during the time of each exposure; a 10-inch coil was used each time except once, when a 6-inch was used. On May 24 the ulcer was noted as being much better. On May 31 there was no discharge. On June 14, when X ray treatment was stopped, all pain had ceased, there was practically no discharge, the nails of the toes were all loose, and a slight erythematous blush extended over the dorsum of the foot and a little up the leg.

The girl could wear a boot and walk about with comfort. No further treatment was adopted until November 15, when Photograph No. 2 was taken. We have only to compare these two photographs to see the great change in the appearance. I am now commencing to give the foot a few more exposures.

Case 2.—C. F., a boy of sixteen (Photograph No. 3), with a large ulcerating lupus attacking the left face and the left ear, with discharge from the ear. It was of five years' duration, and had been constantly scraped and caustics applied with but very temporary benefit; and the lupoid patch was slowly extending in area. On April 18 all treatment was stopped except boracic ointment. Between April 18 and June 14 he was exposed seventeen times, for fifteen minutes each time, to the X rays. The 10-inch coil, with a Newton's tube, the platinum being kept red hot, was used on all occasions except one. The distance of the glass of the tube from the skin was from 4 to 5 inches. After eleven exposures some hair on the side of the head next to the tube began to come out, and was so rapidly shed that in a few days he had an absolutely bald patch, extending in a semicircle from behind the ear upwards to the forehead. The line was a most perfect regular curve; it seemed to me to more or less accurately correspond to the margin of the stream of X rays. At this time the lupus was drying up, so that he was able to leave off the ointment and wear no dressing at all. On June 14, the date of the final exposure, it was practically healed. Seen on August 11, it was quite healed; there was no sign of recurrence, and the hair was growing well again. The beginning of October I showed the boy at the Liverpool Medical Institution, and the dermatologists there, four in number, agreed that the case was quite cured, and that there was no evidence of lupus at all. In this case no other effect occurred beyond the loss of the hair, and this rapidly renewed itself. There was no dermatitis set up either in or around the lupus, and no attempt at protection of the surrounding parts was made. Photograph No. 4 shows the present condition of affairs, taken in November. The scar is white, soft, and healthy looking, and presents no suspicion of any lupoid disease.

In one other case of lupus I have tried this treatment —a boy of eighteen, with a patch of lupus similar in distribution and size to the last case, except that there

was no involvement of the ear, and it was on the opposite side of the face. It was of eleven years' duration, but it was of the dry scaly variety, without any tendency to ulcerate. This case was steadily, notwithstanding scraping it at different times, getting worse and extending. Between June 27 and July 16 he had eighteen applications under similar conditions to the last case, except that the face and head round the lupus were protected with a sheet of lead. At the end of the treatment the patch ulcerated all over, but rapidly healed with boracic ointment. I saw the boy quite recently, and he certainly showed a considerable change for the better, but the case was very far from being cured. He is now undergoing further X ray treatment.

One other case, not my own, I have seen—a young woman with a most malignant type of lupus, affecting the nose, lips, the mucous membranes of the nose and lips, and both cheeks. This case had been repeatedly scraped under chloroform, had had pure carbolic rubbed in, and so on. Only very temporary benefit followed each operation, and rapid relapse took place. Exposure to X rays, without curing, vastly improved this lupus, and she has a fairly long period of considerable relief and benefit following each course of exposures.

Analyzing these cases, the effects produced are somewhat curious. In one case, that of the foot, there was loss of nails and slight erythema. The nails soon grew again, and their loss caused no inconvenience. In the two cases of lupus of the face, in one, the dry, non-ulcerative form, the whole lupoid surface broke down into an ulcer; in the other, the ulcerating case, there was steady healing almost from the very first few applications, and although some of the hair on the scalp was lost, there was never any sign of any inflammatory change of the skin around the lupus, not even the slightest redness. One point was of special interest in this case, and that was the sharp line of demarcation where the hair came out, a curve which might have been drawn with a pair of compasses, and, as I said before, it appeared to correspond very accurately with the margin of the X ray stream, pointing to the probability that it was caused either by the X rays themselves or by some other rays coming off with the X rays. The hair grew again very rapidly, and, if anything, more luxuriantly than before. What the changes produced are is a most difficult question, and, without offering any evidence, I incline to the opinion that a stimulating effect is produced in and around the diseased areas, which enables them to resist successfully the further spread and growth of the disease.

PLATE LXIV. (*c*).

A RABBIT KILLED BY SHOT.

PLATE LXIV. (*d*).

A PARTRIDGE.

Mr. W. R. Cooksen, of Dangstein, Petersfield, writes: These are radiographs of a rabbit and a partridge which were shot here. The rabbit's neck and windpipe are very distinct, and several shots may be seen in the body. No shot can be seen in the partridge, unless it be a splinter in the crop (probably the shot passed through), but it shows a very clear fracture of the wing.

PLATE LXV. (*a*).

A STONE IN THE RIGHT KIDNEY.

Abstract of Notes by Mr. J. ASTLEY BLOXHAM, F.R.C.S.

F. T., aged eighteen, was admitted into Charing Cross Hospital on May 17, 1898, under Dr. Green, with symptoms of stone in the right kidney. These commenced about twelve years ago, but had much increased in severity during the past two years.

On June 18 he was transferred to the care of Mr. Bloxham, and on the 21st, after a skiagram had been taken, a stone was extracted, "the size and shape of which bore out the information given by the skiagram." The size of this calculus was 2 by 1·6 inches; and another was found in the kidney about the size of a small pea.

The patient was discharged from the hospital on July 3 convalescent, and has since then quite recovered, and has been able to perform any ordinary work.

Notes by Mr. MACKENZIE DAVIDSON.

On June 21, 1898, I took a skiagram of the above case. The patient was lying on his back. A Crooke's tube, with an osmium anode, as made for me by Mr. A. C. Cossor, of Farringdon Road, was used, and an Apps' 10-inch spark coil, with Muirhead and Co.'s condenser, working at 12 volts. The anode was placed 32·5 centimetres from the photographic plate.

Two exposures were given on different plates, the tube being displaced 6 centimetres for localization purposes, and to get a stereoscopic picture (*vide* the *British Medical*

Journal, 1898, August 20, p. 481, and December 3, p. 1669). The duration of the exposures was two minutes and twenty-six seconds and two minutes respectively. Edwards' cathodal plates were used.

The reason of the stone appearing so sharp in the negative is due to my only exposing while the patient was in the same phase of breathing, otherwise the motion accompanying respiration would give blurred shadows on the negative.

An image of the stone was seen in each negative, which enabled me to give its exact position and its size. On its removal, the size corresponded to within $\frac{1}{25}$ of an inch of the estimate. It is composed of uric acid, with a thin crust of oxalate of lime.

Since this case I have got skiagrams of three renal calculus cases. In one (a child) three stones are shown.

For the last case (a woman) the Wehnelt interrupter was used, and the stone could be distinctly seen on the fluorescent screen. It was subsequently photographed, but has not yet been operated upon.

PLATE LXV. (*b*).

A STONE IN THE KIDNEY.

PLATE LXVI. (*a*).

A STONE IN THE BLADDER.

PLATE LXVI. (*b*).

A STONE IN THE BLADDER.

THE DETECTION OF CALCULI BY THE ROENTGEN RAYS.

By CHARLES LESTER LEONARD, M.A., M.D., of Philadelphia, Skiagrapher to the Hospital of the University of Pennsylvania, Associate of the Pepper Laboratory of Clinical Medicine.

The detection of certain varieties of calculi has been possible for some time past, but the absolute diagnosis of the presence or absence of all forms of calculi has not.

Experimentation has shown that a heavy or relatively high ampèrage discharge through a "soft" tube produces a quality of Roentgen rays that will differentiate between the less dense tissues. The construction of the self-regulating tube, exhausted to a high vacuum, but capable of being reduced to any desired point, permits sufficient current to be passed through a "soft" tube to produce a volume of Roentgen discharge that will penetrate the lumbar and pelvic regions. We can therefore differentiate between the lesser densities of these regions while the shadow of the kidney and some of the less dense structures of the pelvis can be demonstrated in skiagraphs.

This power of differentiating I have utilized to make absolute both the positive and negative diagnosis in all cases of suspected calculi. Where such detail in the shadows of the softer tissues is possible, we can assert with positiveness that no calculi are present. Clinical experience has demonstrated the correctness of this assertion.

I have made the diagnosis in seventeen cases of suspected calculus. Eleven of these cases were subsequently operated upon, and in each the diagnosis was confirmed in all its details. In five cases the negative diagnosis was confirmed by the exploratory nephrotomy that followed. In six cases the positive diagnosis was confirmed, while multiple calculi were removed in three of those cases. One case has already appeared in the ARCHIVES (vol. ii., No. 4). The accompanying skiagraphs illustrate two of the other cases: in one is a small calculus, in the other there are three calculi.

Case I. [Plate LXV. (*b*)] was referred to me by Dr. James Tyson. There was only a suspicion of calculus, as the only symptoms were indefinite lumbar pain, and a small amount of albumin and pus in the urine. The subsequent operation, performed by Dr. J. William White, was based upon the skiagraphic diagnosis, and demonstrated its correctness. The patient made a complete and rapid recovery.

A second case was referred to me by Dr. Edward Martin, who made a diagnosis of stone. The patient had suffered for a long time, and had been examined by numerous surgeons; the symptoms had not been sufficiently marked to justify a diagnosis of stone, and but one of the surgeons has suggested exploratory nephrotomy. (We regret that the lithographer was unable to print this case, as the photograph of the stones was very faint.—EDS. ARCHIVES.)

The skiagraph shows one large and two very small calculi. The nephrolithotomy performed by Dr. Martin confirmed the diagnosis in every detail. Without the evidence given by the skiagraph the operation would have been incomplete, as the two smaller calculi were found in a diverticulum of the inferior calix, that could only be reached by an incision which was based on the details given by the skiagraph. The patient made a complete and uninterrupted recovery.

The cases of vesical calculus illustrated in Plates LXVI. (*a* and *b*) are from a series that has demonstrated the possibility of detecting all forms of, and even very minute calculi in the bladder. Although the diagnosis could be easily made by the other methods of diagnosis, the information gained regarding the number, size, and location of the calculi was found to be of very great value, leading in one case to the removal of an encysted calculus where three were present.

1930, Chestnut Street, Philadelphia, U.S.A.

PLATE LXVII.

EXOSTOSIS OF THE FEMUR.

Description by Mr. JONATHAN HUTCHINSON, Junr., F.R.C.S.

The tumour was a solitary exostosis (that is, the only one in the body) and occurred in a postman aged twenty-seven. It had grown many years, and was well pedunculated and composed of fairly soft cancellous bone, with a thick cap of cartilage. The medullary canal of the femur communicated with the cancellous spaces in the pedicle; the muscles on the front of the thigh were lifted up and displaced by the tumour. The latter was removed in the London Hospital by Mr. Hutchinson, it being found advisable to saw the mass into two during the operation. The patient made an uncomplicated recovery.

PLATE LXVIII. (*a*).

A FRACTURE OF THE UPPER END OF THE HUMERUS WITH DISLOCATION.

Reported by Dr. THOMAS JOYCE, Cranbrook.

E. S., aged twenty-four years, a stout-built, muscular young man, was thrown from his horse on the night of January 17, 1898, and fell heavily on his outstretched left hand. He was seen by a local surgeon about three hours after the accident, who diagnosed a dislocation of the shoulder, made some manipulations of the arm, and stated it had been reduced. The arm was bound to the side for a short time, and afterwards carried in a sling.

As the shoulder remained unsymmetrical and the arm comparatively useless, in the following April he consulted Mr. Wilkinson, of Ashford, the family surgeon, who found the dislocation still unreduced, the head of the humerus being firmly fixed in the subcoracoid position. He was put under ether, and an attempt made to effect reduction, which was unsuccessful. A second attempt, under chloroform, at which Mr. Colville assisted, was made on April 19, which also failed.

In May he was seen by Mr. Wharton Hood, of London, who also placed him under ether, but was unable to bring the head of the humerus into position.

At the present time, a year after the accident, the condition is as follows: The aspect of the shoulder is markedly rectangular, owing to the sharp relief into which the ridge of the acromion is thrown by the atrophy of the deltoid muscle; the biceps is seen to be also considerably wasted. Below the outer third of the clavicle a hard round prominence marks the position of the coracoid process, and further outwards, below and slightly external to the glenoid cavity, there is felt another hard process, which can be traced downwards towards the shaft of the humerus. As regards the range of motion, the arm can now be approximated to the side, swings easily and painlessly backwards and forwards, can be raised to an angle of 75° with the trunk; the hand can be placed on the top of the head, and the fingers on the opposite shoulder; the forearm can also be placed behind the back.

On October 5 a radiograph of the shoulder was taken by Mr. Wilson Noble, which showed the head of the humerus still fixed in the subcoracoid position; but it also showed that, in addition to the dislocation, a longitudinal fracture had occurred, commencing at the greater tuberosity and extending some way down the shaft of the bone. At that date the new bone thrown out by the periosteum to unite the splintered off piece with the shaft had not sufficiently hardened to entirely obstruct the rays, so that a semi-opaque streak fills up the space between the hard bone of the fragment and that of the shaft.

Another radiograph was taken on December 19, and it was then seen that complete bony union had considerably advanced, a dense dark line having replaced the light streak shown in the one taken on October 5; but the head of the tuberosity still remained distinct.

PLATE LXVIII. (*b*).

SUBLUXATION OF THE KNEE-JOINT.

Notes by Dr. ROOME.

This case of a rare accident was sent me by Dr. Ward Cousins, of Southsea. The patient, a young man, had been kicked on the front of the tibia by a

horse. The joint was fixed in a slightly flexed position while the head of the tibia was displaced obliquely backwards.

The radiograph shows dislocation downwards of the tibia and fibula. The ligamentum patellæ is ruptured, with the internal crucial ligament, and there appears to be also some amount of rotation of the bones.

The dislocation has since been reduced.

We intend in future to show the original radiographs, from which our illustrations are taken, at the meetings of the Röentgen Society.—EDITORS.

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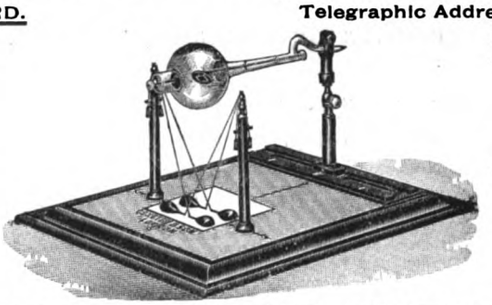

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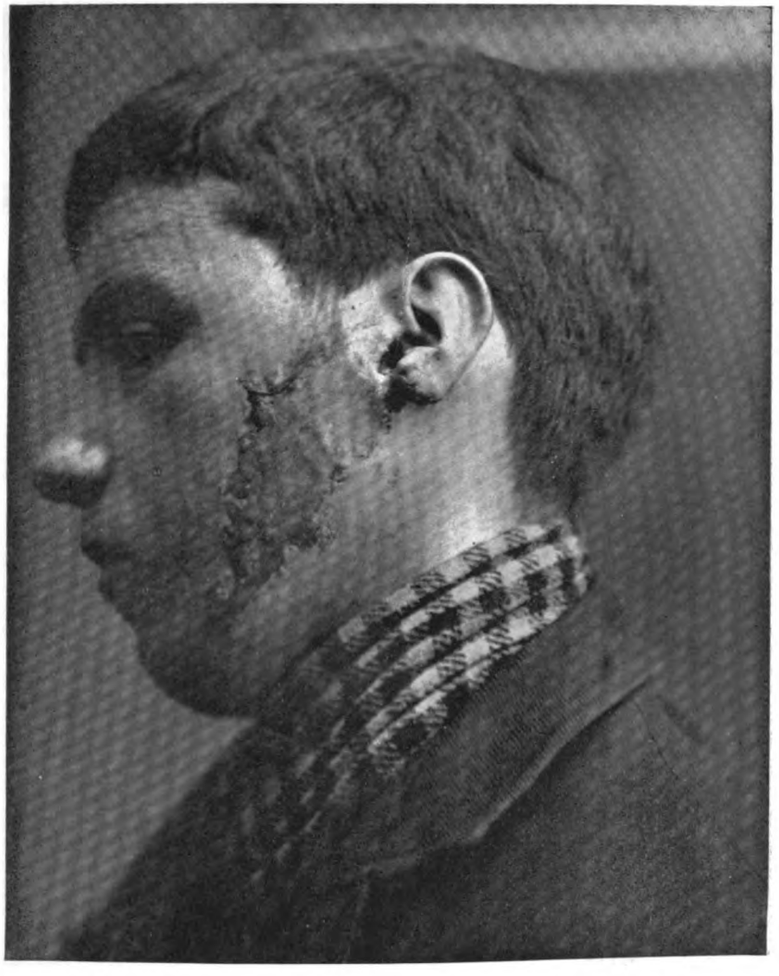


LUPUS OF THE FACE, BEFORE TREATMENT.

Dr. THURSTAN HOLLAND'S Case.

PLATE LXIII. (*a*).

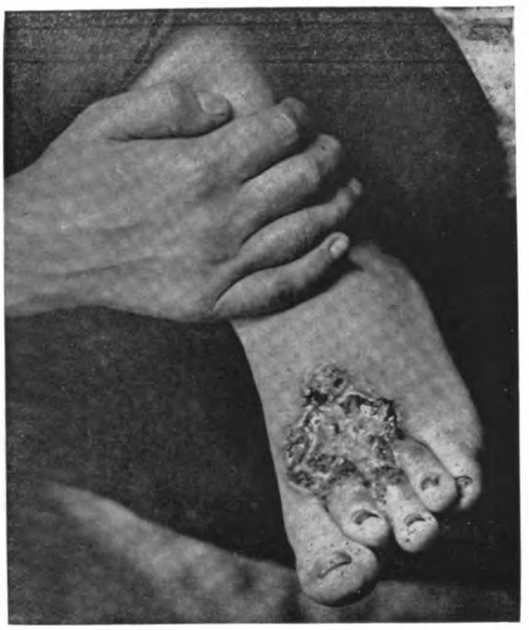
("*Archives of the Roentgen Ray.*"—*Copyright.*)

LUPUS OF THE FACE, AFTER TREATMENT.

Dr. THURSTAN HOLLAND'S Case.

PLATE LXIII. (*b*).

("*Archives of the Roentgen Ray.*"—*Copyright.*)

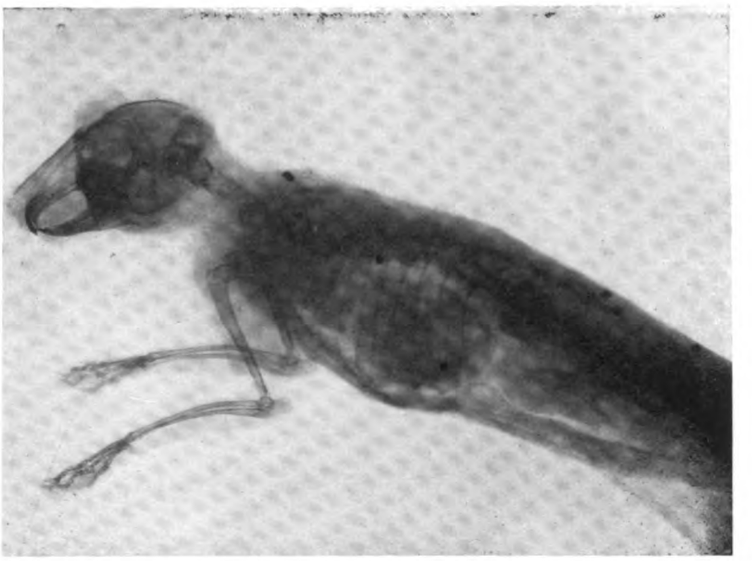


LUPUS OF THE FOOT, BEFORE TREATMENT.

Dr. THURSTAN HOLLAND'S Case.

PLATE LXIV. (*a*).

(*"Archives of the Roentgen Ray."—Copyright.*)



A RABBIT WHICH WAS KILLED WITH SHOT.

Radiographed by Mr. W. R. COOKSEN.

PLATE LXIV. (*c*).

(*"Archives of the Roentgen Ray."—Copyright.*)

LUPUS OF THE FOOT, AFTER TREATMENT.

Dr. THURSTAN HOLLAND'S Case.

PLATE LXIV. (*b*)

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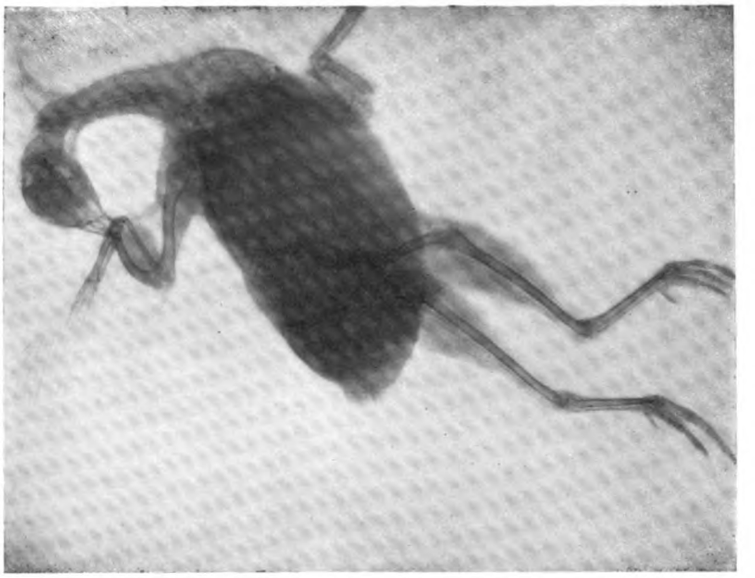

A PARTRIDGE WHICH WAS KILLED WITH SHOT.

Radiographed by Mr. W. R. COOKSEN.

PLATE LXIV. (*d*).

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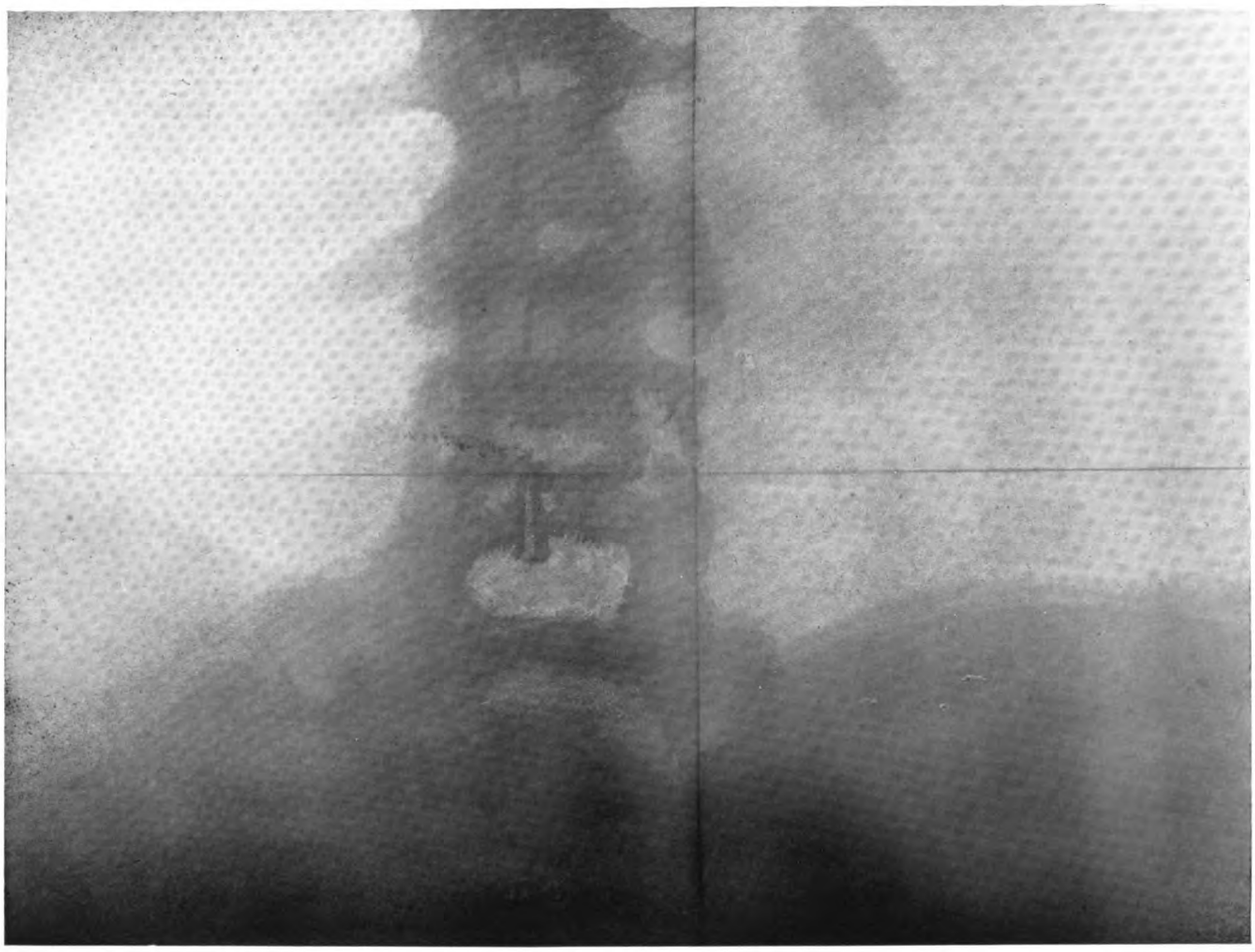
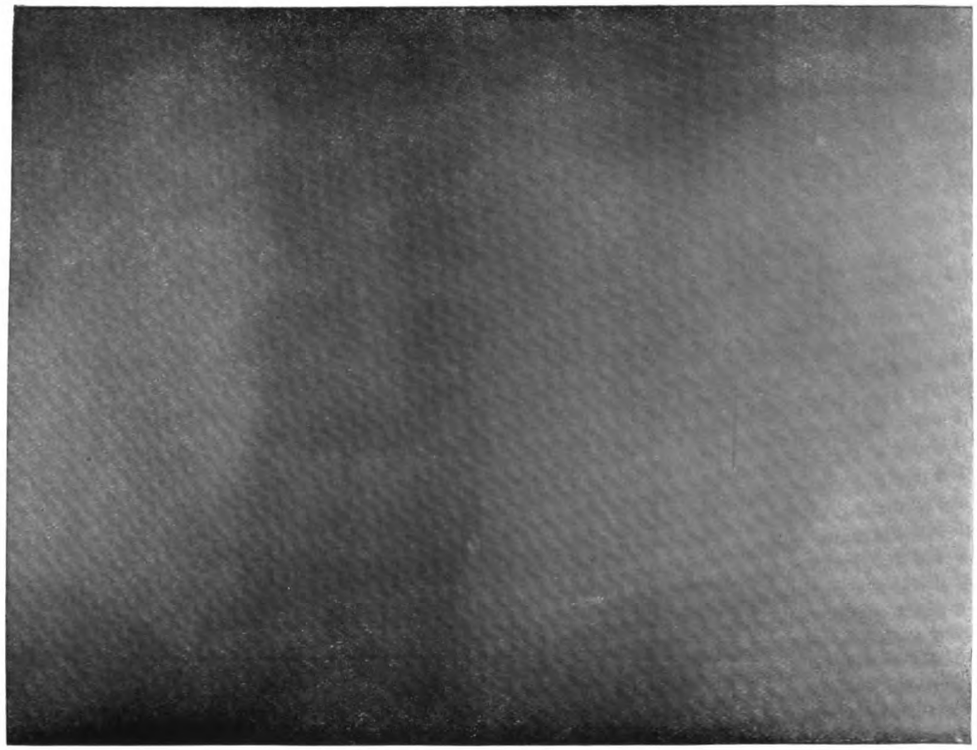


A STONE IN THE RIGHT KIDNEY.

Mr. J. ASTLEY BLOXHAM'S Case. Radiographed by Mr. MACKENZIE DAVIDSON at Charing Cross Hospital.

PLATE LXV. (*a*).

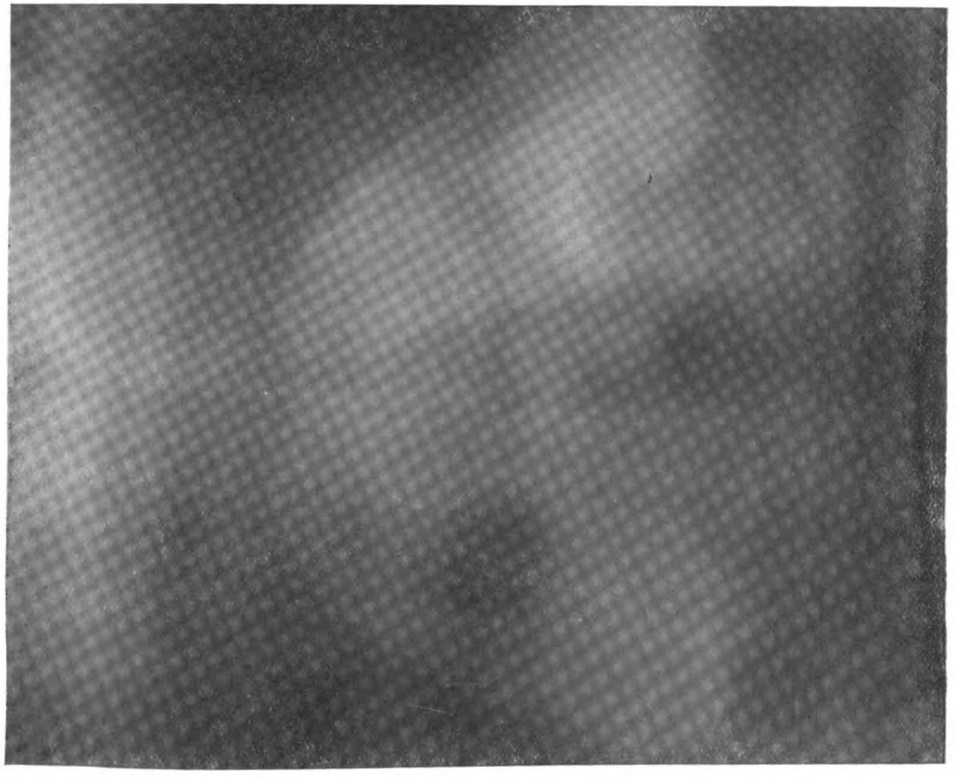
("*Archives of the Roentgen Ray.*"—*Copyright.*)



A STONE IN THE RIGHT KIDNEY.

CASE NO. 1 IN DR. LENNARD'S PAPER.

PLATE LXV. (*b*).



A STONE IN THE BLADDER.

Case No. 3 in Dr. Lennard's Paper.

Plate LXVI. (*a*).

("*Archives of the Roentgen Ray.*"—*Copyright.*)

A STONE IN THE BLADDER.

Case No. 4 in Dr. Lennard's Paper.

Plate LXVI. (*b*).

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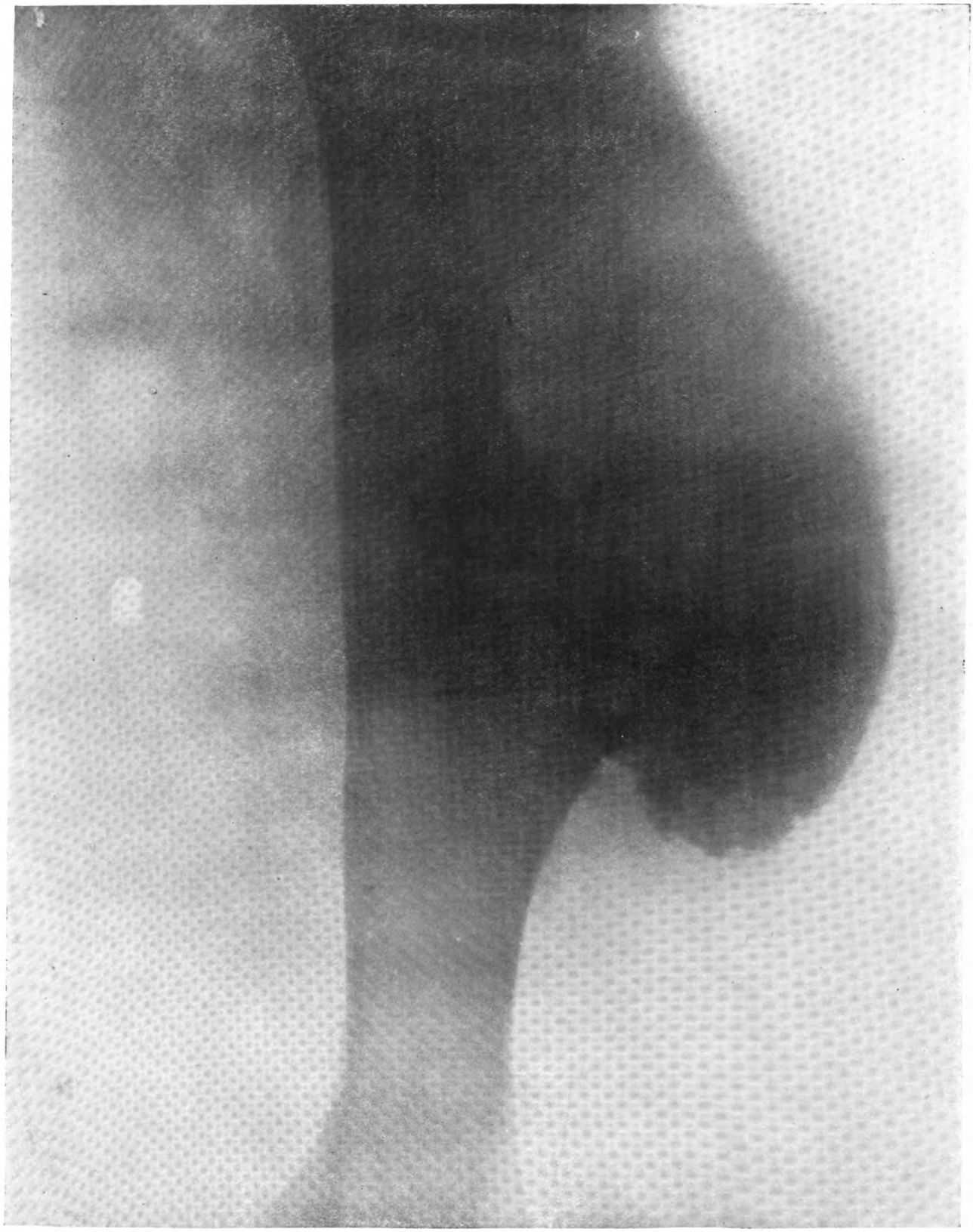


EXOSTOSIS OF THE FEMUR.

Mr. JONATHAN HUTCHINSON Junr.'s Case.

Radiographed in the X Ray Department of the London Hospital.

Principal: Dr. W. S. HEDLEY. Assistant: Mr. ERNEST H. HARNACK.

PLATE LXVII.

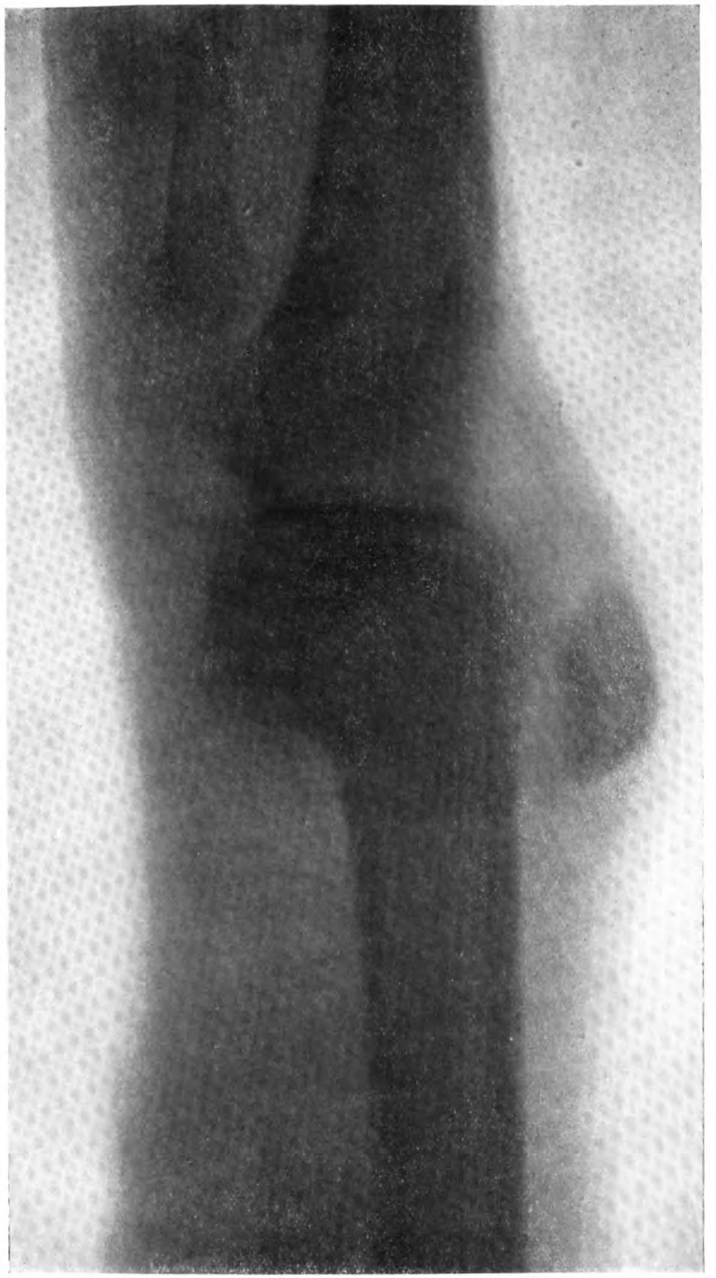
(*"Archives of the Roentgen Ray."—Copyright.*)

AN UNREDUCED DISLOCATION OF THE SHOULDER, WITH FRACTURE OF THE HUMERUS.

Mr. THOMAS JOYCE'S Case. *Radiographed by Mr. WILSON NOBLE.*

PLATE LXVIII. (*a*).

("*Archives of the Roentgen Ray.*"—*Copyright.*)



SUBLUXATION OF THE KNEE-JOINT.

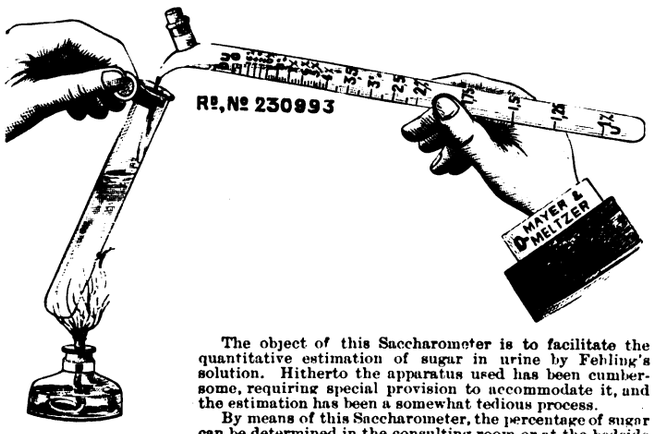
Dr. WARD COUSIN'S Case.

Radiographed by Dr. HENRY A. ROOME.

PLATE LXVIII. (*b*).

("*Archives of the Roentgen Ray.*"—*Copyright.*)

CARWARDINE'S SACCHAROMETER.



The object of this Saccharometer is to facilitate the quantitative estimation of sugar in urine by Febling's solution. Hitherto the apparatus used has been cumbersome, requiring special provision to accommodate it, and the estimation has been a somewhat tedious process.

By means of this Saccharometer, the percentage of sugar can be determined in the consulting room or at the bedside in a few minutes, and without calculation.

PRICE (with full instructions) 8s. post free.

M. & M. (No. 1) QUANTITATIVE TEST CASE,
Containing Carwardine's Saccharometer, Doremus' Ureameter, Esbach's Albumen Tube. **PRICE £1 1s.**

M. & M. (No 2) QUANTITATIVE TEST CASE,
Containing Carwardine's Saccharometer, Mayhew's Ureameter, Esbach's Albumen Tube. **PRICE £1 5s. with full instructions.**

MAYHEW'S UREAMETER.

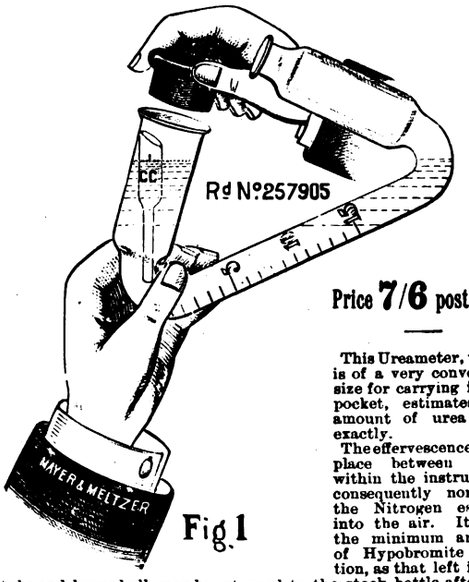


Fig 1

Price 7/6 post free.

This Ureameter, which is of a very convenient size for carrying in the pocket, estimates the amount of urea very exactly.

The effervescence takes place between fluids within the instrument, consequently none of the Nitrogen escapes into the air. It uses the minimum amount of Hypobromite Solution, as that left in the tube and lower bulb may be returned to the stock bottle after the test as it is unused.

SOLE MANUFACTURERS:

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RUHMKORFF COILS. 3-inch Spark £9; 4-inch Spark £12.

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NEWTON'S X RAY "FOCUS" TUBES.

A NEW method of making Tubes for photographing with the X rays has been devised in the Chemical Laboratory at King's College, by which these rays are apparently brought to a focus, while the definition is so much improved that many details in the bones themselves are brought out clearly, at the same time the length of exposure is greatly reduced.

Price of "Focus" Tubes, with directions for use ... ... **35s. each.**
The above are suitable for Coils giving 2 in. spark and over.

Price of SPECIAL "Focus" Tubes, with directions for use ... ... **42s. each.**
The above are suitable for Coils giving from 7 in. to 10 in. sparks, and are specially made for use with Fluorescent Screens.

COMPLETE SETS OF APPARATUS FOR RÖNTGEN "X" RAY WORK.

THE following Sets are the most efficient for their purpose that we can supply. It is not advisable to use Tesla coils and currents of high voltage. The No. 1 Set is perfectly efficient for photography. First-rate photographs of the bones in the hand, arm and wrist can be made with it, giving about two minutes' exposure, showing a great deal of detail in the bone itself.

No. 1.—Complete Set for "X" Ray Photography, comprising Battery, Coil, and Focus Tube ... ... **£18 18s.**
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FLUORESCENT SCREENS.

With these Screens the bones in the hand, arm, or body can be easily *seen* if placed in the path of the "X" Rays.

Fluorescent Screens, 6 in. diameter, mounted in Ebonite and Aluminium ... ... **each £4 4s.**
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Storage Batteries, Bunsen and Grove's Cells, &c., in Stock.

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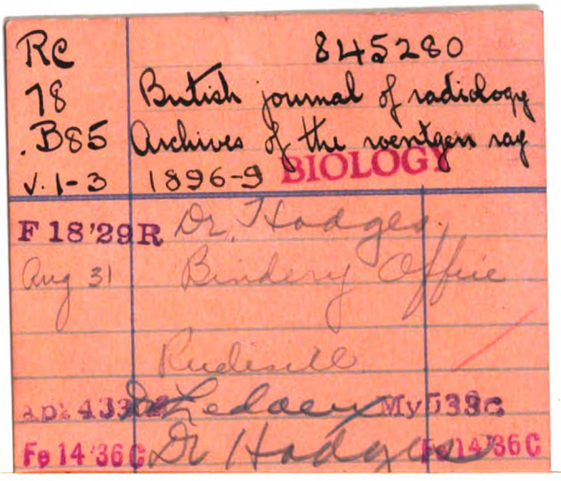
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